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POPULAR
SCIENCE

I

PAGES
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The Triumphs of Inventive Genius
The Story of all Created Things and
the World They Live In

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I

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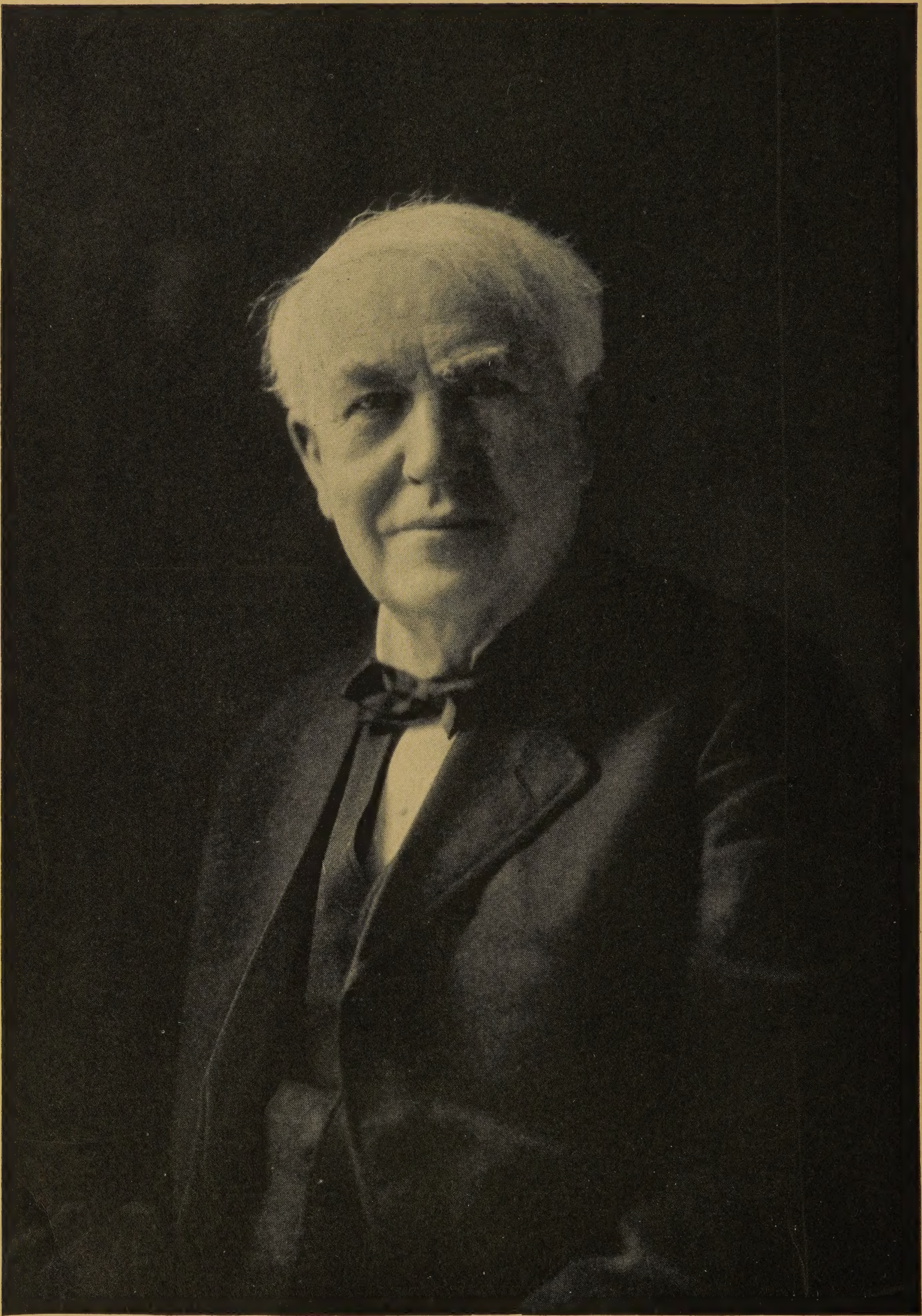

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TOTAL SOLAR ECLIPSE, SEPTEMBER 10, 1923

This painting shows the dark disc of the moon, hiding the sun. It is surrounded by the greenish-gray corona, extending outward, from the concealed sun, far into space. The planet Venus appears almost vertically above the moon. Around the edge of the disc are a few small hydrogen prominences, or flame-like projections of the red solar chromosphere; and, on the upper edge to the right, is seen the first "Baily Bead" of the third contact — a tiny speck of the sun itself, marking the end of totality, so brilliant that the unprotected retina magnifies it into an apparent ball of orange fire, complementary in color to the blue-greens of sky and corona. For an instant, that chosen by the artist, all these phenomena were simultaneously visible. Immediately thereafter all gave place to a string of beads coalescing into a crescent.

The Universe

THIS is a list of a few of the subjects explained and illustrated in the first of the great departments into which The Book of Popular Science is divided. The index at the end of volume XV gives ready clue to the many others which treat of the wonders of astronomical research and the story of the countless heavenly bodies which make up the marvel of the Universe in which the globe we live on is such a tiny speck. The heavy face type indicates chapter headings.

Outer Parts of the Sun
The Sun's flaming and pearly mantles
How can the Moon totally eclipse the Sun, with a diameter 400 times greater?
The Sun's elusive corona and the difficulty of observing it

Problems of the Moon
Earth's near neighbor in the skies
Why the Moon always keeps the same face towards us
Sunlight reflected by the Earth upon the Moon 20 times as strong as our moonlight

The Surface of the Moon
The universe as seen from the Moon
Is there volcanic activity on the Moon now?
Shadows show craters as high as 25,000 feet
What the "man in the Moon" sees in the sky

Shadows in the Heavens
Does gravitation bend light rays?
When and why eclipses occur
The Earth casts a shadow 871,000 miles
Eclipses of the Sun more numerous than of the Moon but seen by fewer people
The theory of relativity and eclipses

Companions of the Sun
The planets inside the Earth's orbit
The day and year on Mercury of equal length
What is meant by "the transit of Mercury"
Why is Venus, so far away, 50 times brighter than any other star in our sky?

Our Foothold in Space
The wonder of the aurora borealis
How we know the earth is round and rotates
Is the Earth gradually losing its supply of water? If so, what will happen?

Mars and the Minor Planets
Theory and knowledge about Mars
100 pounds on Earth weighs but 38 on Mars
Is there a Martian superman and are the channels his canals?
The tiny moon that rushes madly round Mars three times a day
What are asteroids and how formed?

A Sub-Lord of the Heavens
The size, velocity, satellites of Jupiter
A planet 119 times the area, 1300 times the volume of the Earth
Jupiter, traveling 28,800 miles an hour, takes 12 years to complete its orbit

Saturn the Magnificent
A planet less dense than water
Magnificence of the encircling rings and ten satellites
What are the rings made of?

The Outermost Planets
Problems of the planetary system
The peculiar orbits of Uranus' moons
Why we can see Neptune but not Neptune us
Why the density of planets differs

A Cosmic Bombardment
The celestial messengers' story
Shooting stars meteorites which encounter the atmosphere of the Earth
What do meteorites consist of?

Wandering Fire-Mists
Visitors too swift and fine to be known
Periodic revisitations of certain of the comets
Jupiter has 34 with periods of 3 to 8 years
The tail of a comet follows its head when approaching but precedes it when receding from the Sun

The Stars in their Courses
Why stars twinkle and planets do not
Stars that appear near together often are millions of miles apart
"Magnitude," in astronomy, indicates brilliancy, not size

A Star's Life History
The message brought to us by light
The apparent immobility of the stars shows how far away they must be
Their lighting powers to reach us proves them suns of enormous size and brilliancy

Problems of Star Land
What dark stars range the sky unseen
The "wonderful" star that varies between the 1st and 10th magnitudes
Regular "eclipse variables" caused by a companion passing between them and us
Famous examples of brilliancy and decline

The Grouping of the Stars
New wonders seen with the field-glass
Double stars, double-doubles and unexplained clusters
Relationship based on physical affinities
How we see in the spectroscope what can never be seen in the heavens

A Secret Universal Plan
Movements and distances of stars
Are stars that seem to move fastest those nearest us?
Where is our Sun headed for?
How is a star's distance calculated?

Sun Clusters and Nebulæ
The gorgeous diadem of the Pleiades
Alcyone, chief star of the group, a luminary 200 times more powerful than the Sun
Dark nebulæ known to us only by their shadows

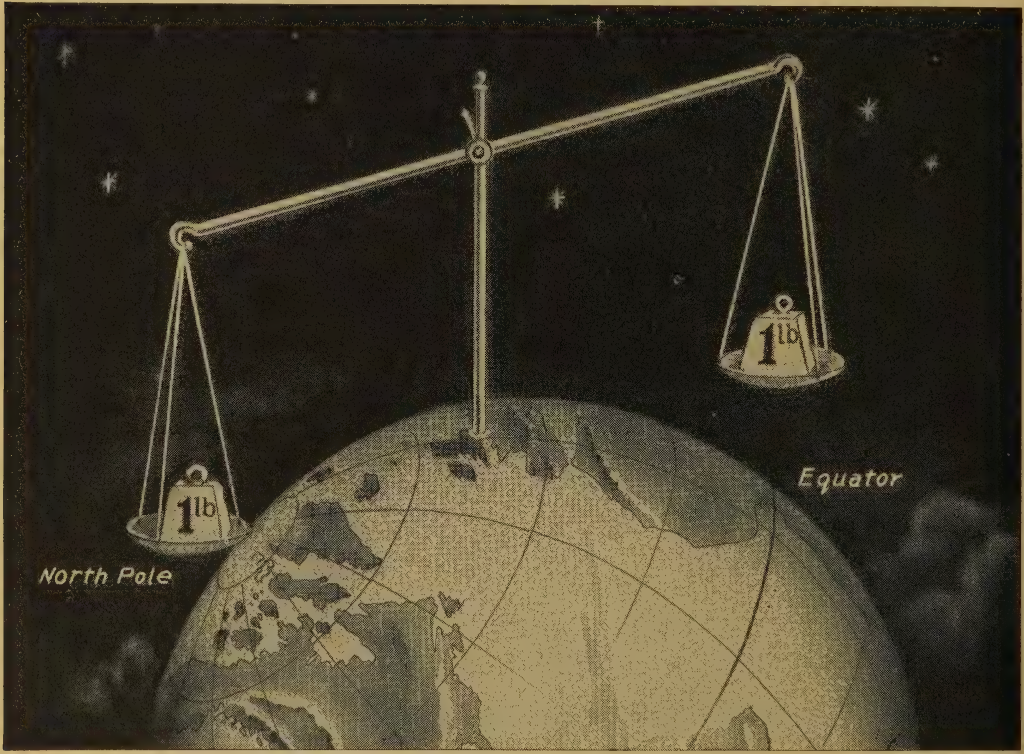
The Wonderful Milky Way
A circling zone powdered with stars
Dark rifts in the sky where no stars appear
A pulse of light traveling 186,000 miles a second would take two or three thousand centuries to go from one confine of the Milky Way to the other

HOW DISTANCES OF STARS ARE ASCERTAINED

The parallax of a star is the angular measure of one-half the major axis of the apparent annual orbit which it performs as seen from the earth. Every star has a parallax, but only relatively few parallaxes are measurable; most stars, owing to their great distance, having practically infinitesimal apparent displacements. For instance, in the lefthand diagram the star *X*, when viewed from the earth in June, appears at *b* in relation to the more distant stars 1 and 2, which have practically no parallax, but in January it appears at *a*. The observed value of the major axis of the apparent ellipse performed by the star *X* bears a definite relation to the diameter of the earth's orbit and enables astronomers by mathematical calculation to find out the actual distance of the star from the earth. The righthand diagram shows the smaller parallax of the more distant star *Y*.

the earth the apple, we may note next the clause which declares that the force of gravitation is exactly measurable, and is proportioned to the quantity of matter in action. Thus if we consider any two bodies, one known and the other unknown, and try to study the force of gravitation between them, we must observe the motion of the body we know; and since all variation of motion involves the action of force, we can infer the gravitational force at work to produce the motion we observe. But if we know the position and mass of the body we see, we are now enabled by the law of gravitation to infer the position and mass of the body we do not see, if we also take into account the law as to distance which concludes Newton's statement. This is the fashion in which Neptune and also the dark companions of many stars have been discovered; and in this way too we may later on discover a possible planet outside Neptune, such as some astronomers are now suspecting to exist.

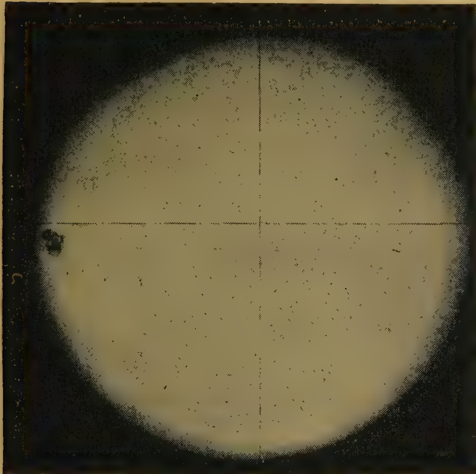
Observe that Newton's law speaks not of weight but of mass. To understand the distinction is essential for all this department of science. The mass of anything is the quantity of matter in it. This is a fixed amount, so to speak, of the thing in question and remains unchanged as long as nothing is added to or taken from the body. This is strictly true in the Newtonian sense, though modern research seems to indicate a very slight increase in the apparent mass of a body — that is, in its inertial effects — when it is moving at enormously high velocities. The weight of a body, on the other hand, is the measure of the force of attraction existing between it and the earth, or to speak more generally, between it and the celestial body on which it happens to be placed. It is therefore something changeable. It is due to gravitation and depends not only on the mass of the body itself but also on the mass of the attracting body and on the distance between them. If we hold a mass in our



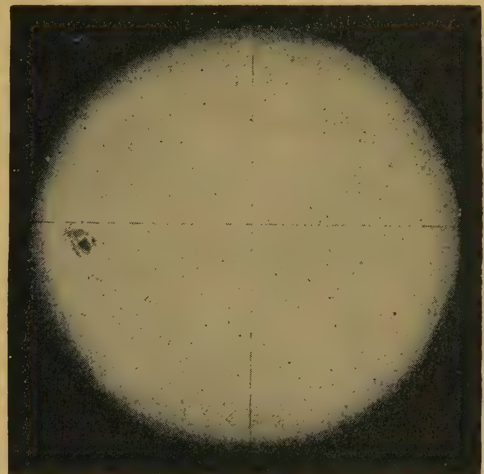
WHY EVERYTHING LOSES WEIGHT AT THE EQUATOR

The earth bulges at the equator and is flattened at the poles, the distance from the North Pole to the center being about 13½ miles less than the distance from the equator to the center. The pull of gravitation is less at the greater distance, and so a balance with one pan at the pole and the other at the equator would show that of two *equal masses* the one at the equator would have *less weight* than the one at the pole.

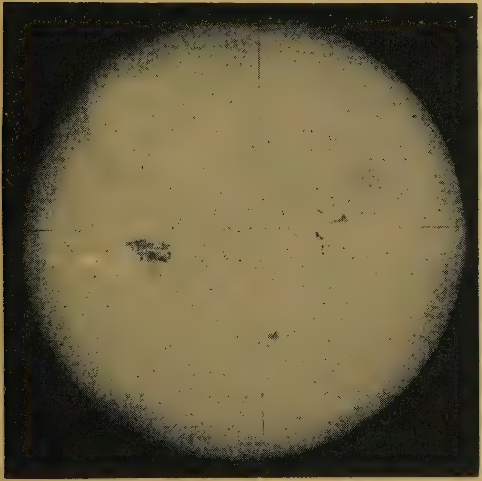
SUN-READING BY PHOTOGRAPHY



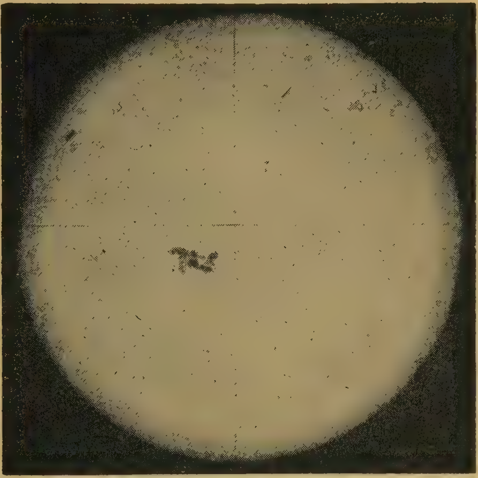
First day—January 30



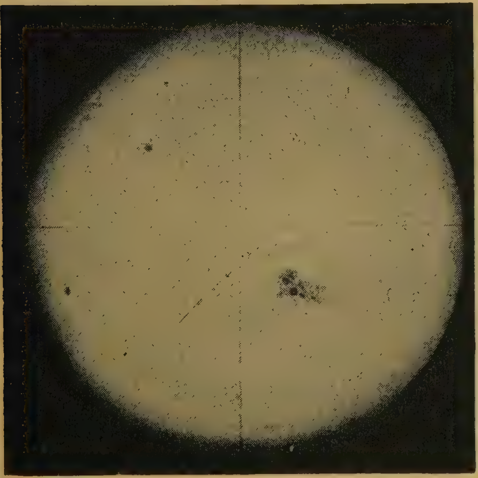
Second day—January 31



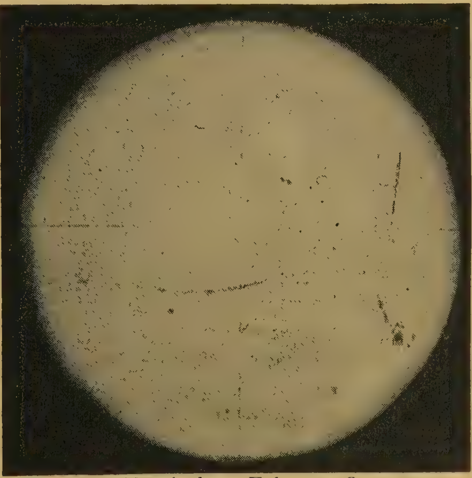
Fourth day—February 2



Fifth day—February 3



Seventh day—February 5



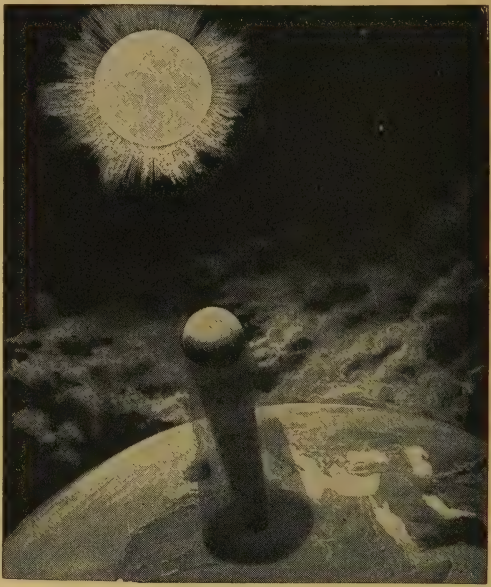
Tenth day—February 8

TEN DAYS' PHOTOGRAPHS OF SUN-SPOTS IN 1905, SHOWING THAT THE SUN REVOLVES

These beautiful photographs, taken at the Royal Observatory, Greenwich, are reproduced by permission of the Astronomer Royal.

The moon is usually not altogether lost to sight even in the midst of a total eclipse, but shines with a strange, lurid, copper-colored glow. Although the earth's globe, so much larger than the moon, is interposed directly between it and the sun, yet sunlight reaches the moon's surface with sufficient illumination to show up the main lunar features. This is sunlight which has been deflected by the earth's atmosphere. When we witness from the earth a total eclipse of the moon, observers on the moon would see a total eclipse of the sun, but they would see the great ball of the earth surrounded all round its edge by a glowing ring of sunlit atmosphere; and the rays which would thus reach their eyes constitute the light that illumines the moon during total eclipse. The terrestrial atmosphere acts as a lens, bending some of the sunlight which passes through it into the shadow of the earth. If, however, the earth's atmosphere be heavily laden with clouds, and is consequently comparatively opaque, it fails to deflect sunlight into the earth's shadow; and under those conditions the moon's surface may be so obscured as to be altogether invisible. The lurid, ruddy color during an eclipse is due to the quality of the atmosphere to which we owe the gorgeous tints of sunset. The light which thus passes from the sun to the eclipsed moon has obviously had to traverse more than twice the distance through the atmosphere which the rays of the setting sun have to traverse before they reach our eyes; and the tinting effect of the atmosphere, with which we are familiar in sunsets, is more than doubled.

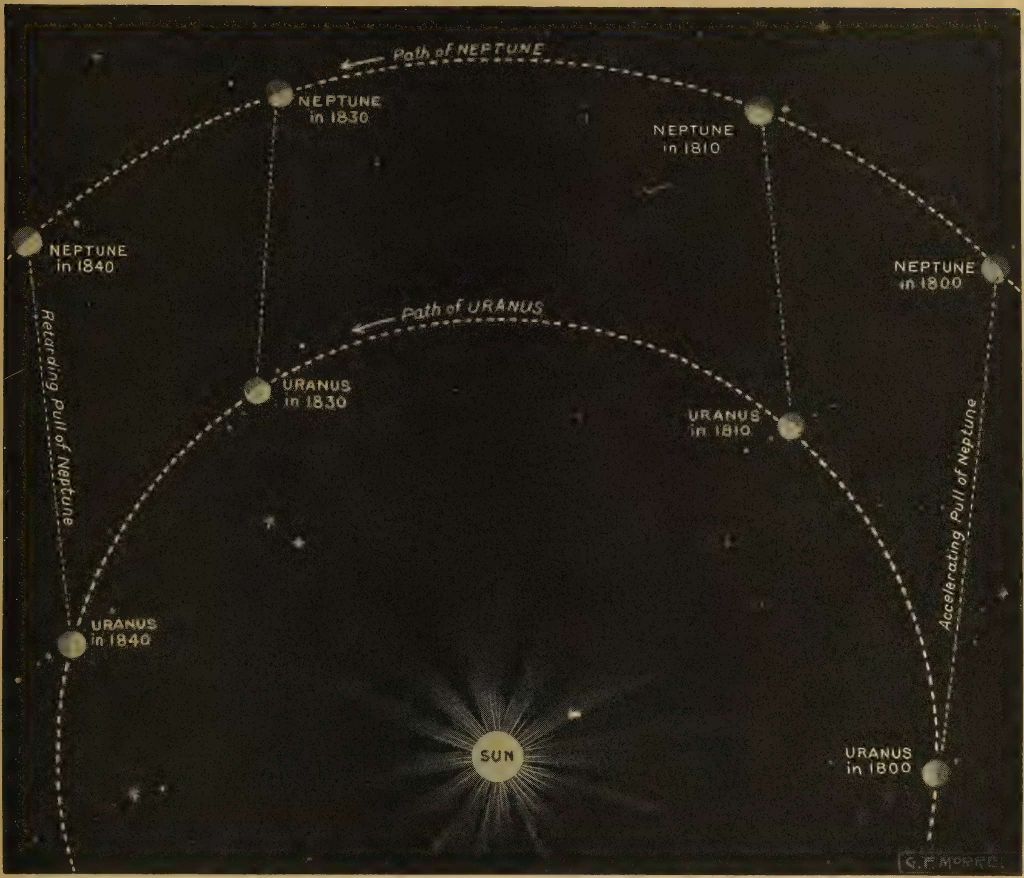
Eclipses of the moon are not quite so frequent as eclipses of the sun. There are years within which there is no eclipse of the moon; and in general it may be said that there cannot be more than two lunar eclipses in any one year. If, however, there is an eclipse of the moon on one of the first days of the year, it is possible that there may be a third eclipse in December. The statement that eclipses of the sun are somewhat more frequent than eclipses of the moon seems to be contrary to our experience, for everyone must have noticed that in the country where he lives eclipses of the moon are considerably more frequent than eclipses of the sun. These two facts are not really in contradiction with one another. The moon's shadow, as it reaches the earth, covers only a very small space, whereas the earth's shadow, as it reaches the moon, is more than twice the moon's diameter. Every eclipse of the moon is therefore visible to the inhabitants of more than one-half the earth's surface, but the regions from which any particular eclipse of the sun can be seen lie in a very narrow track across the globe.



A SOLAR ECLIPSE VIEWED FROM SPACE

Astronomers have to undertake expeditions to remote corners of the world to study eclipses of the sun, but eclipses of the moon can be seen at home. Yet, from the astronomical point of view, eclipses of the sun are incomparably more important, as well as more frequent. There are at least two solar eclipses every year, and there may be as many as five.

Inasmuch as eclipses both of the sun and of the moon depend upon the regular movements of these bodies, their occurrence, both in the future and in the past, can be calculated with great exactness. Thus we know from published tables, of which the best known are Oppolzer's, that within the next ten years total eclipses



THE DISCOVERY OF A NEW PLANET BY MATHEMATICS — A TRIUMPH OF THE HUMAN MIND

This drawing explains how mathematicians were able to infer the existence of a new planet, which was afterwards found in the precise place expected. It was observed that the planet Uranus traveled much faster and farther between the years 1800 and 1810 than between 1830 and 1840, and it was imagined that this was due to the pull of a then unknown planet, which accelerated the motion of Uranus at the earlier date, and then retarded it after Uranus had passed a particular point in 1822. Mathematical calculations led a great astronomer to turn the telescope to a particular place in which the unknown planet was supposed to be, and there, in 1846, the planet Neptune was discovered, a thousand million miles beyond Uranus, and more than twice that distance from the earth.

Kepler's statements of planetary motion, therefore, are not strictly accurate, for this motion is complicated by the attraction of the planets for each other. They do not move as if under the influence of a force solely centered in the sun. Thus the planet Uranus was found to behave in a somewhat different way than it should strictly according to Kepler's laws, as if some other unknown celestial body were complicating its motion. If the law of gravitation simply asserted that the sun attracts the planets, it would not be the key to this case, but it asserts that all matter attracts all matter. Hence, the presence of another body, outside the sun, might be inferred to account for the abnormalities in the movement of Uranus.

Two astronomers made the necessary calculations assuming the truth of Newton's law, and they were duly rewarded by the discovery of the hitherto unknown planet Neptune, according to their predictions. This was alike one of the most notable achievements of science, and the most perfect imaginable illustration of the ideal methods of knowledge — which are the combination of the method of deduction from general to particular, with the method of observing particulars, and inferring from these the general law to which they conform.

If we do, indeed, realize the universal character of Newton's generalization, and how incalculably it transcends the mere notion that the sun attracts the planets, or

That is enough for us at present, regarding the moon — that it is now waterless, and must once have had water.

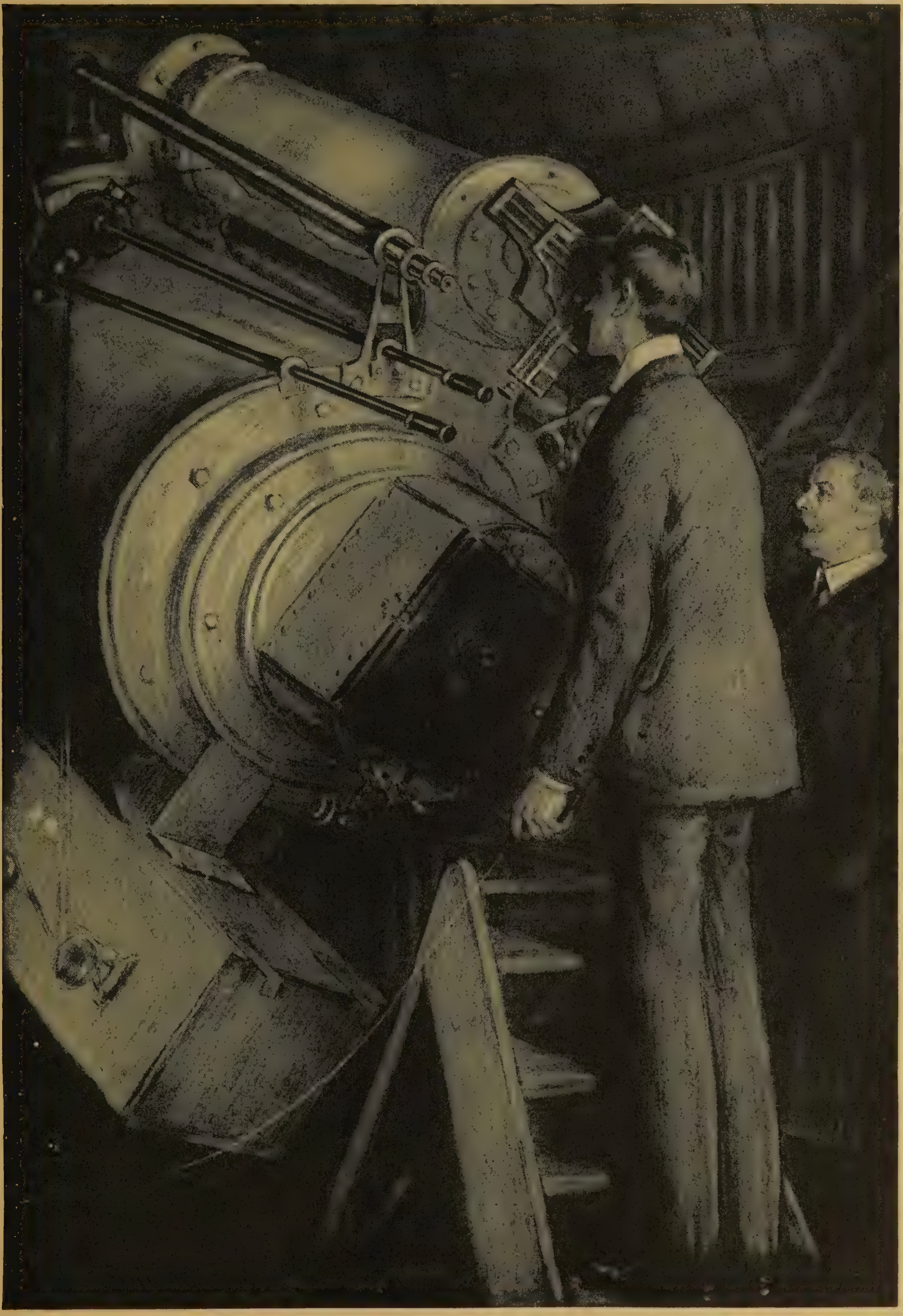
Closely similar is the evidence of the surface of Mars, a planet which, though larger than the moon, is much smaller than the earth. No problem is here, as in the larger planets, of trying to peer through a dense atmosphere. The moon has no atmosphere at all, and nakedly displays its arid surface. The surface of Mars is scarcely less visible, and there, also, are features which were confidently taken for oceans and seas when they were first observed, but which we know are now quite dry. Astronomers can no longer doubt that water is present in Mars; but the fact that this was very doubtful, and that only the genius and patience of Lowell and his helpers were able, by delicate spectroscopic evidence, to demonstrate it, suffices to show what an extraordinary contrast there certainly is between the surface of Mars and the surface of the earth in this vitally important respect.

THE BED OF AN OCEAN ON THE MOON, SHOWING ITS FLATNESS

The presence of some water upon Mars may be demonstrable, and may be of overwhelming importance from the point of view of the possibility of life upon Mars; but the astonishing scarcity of whatever water there may be, together with the evidence of abundant former water, and the similar evidence derived from the moon, entirely justifies the assertion that, in the course of its sun-sustained stage, a small planet loses its water.

We shall not here enter upon the arguments adduced for and against the thesis that the earth also must finally become absolutely waterless. The balance of evidence may, perhaps, appear to incline to the view that the earth is slowly losing its water, as the moon and Mars have certainly done. At least we are entitled to say that, whatever the geologists may find definitely shown by the earth, the astronomical evidence, as we have outlined it, creates a very strong presumption in favor of the view that the earth must be going through a similar evolution to

MEASURING THE TIME BY THE STARS



THE LARGE TELESCOPE USED AT GREENWICH OBSERVATORY

The upper tube is used for observing the stars, by the apparent movements of which in the heavens exact time is measured. The lower, larger tube is used for solar photography.

undertakes a measurement of time, the exact position he occupies on the surface of the earth, and the exact position in the skies of the heavenly body that he is studying. This enables him to calculate exactly the correct time. The mariner, on the other hand, knows from his chronometer what the time is to within a fraction of the truth; and he is then able to learn, by an observation taken with an instrument he carries, his exact position on the ocean. At noon, by means of an instrument called a sextant, he measures the angle at which the sun is at its highest above the horizon; and knowing from his Nautical Almanac at what angle the sun is above the equator, he can quickly calculate the latitude of his ship — that is, how far north or south it is. But in order to find out his longitude — that is, how much east or west he is of Greenwich — he must, of course, have a chronometer that keeps Greenwich time.

SHIP'S OFFICERS TAKING THE SUN AT MIDDAY IN MID-ATLANTIC BY MEANS OF A SEXTANT

If his watch is two minutes out, he will miscalculate the position of his ship by half a degree of longitude — that is to say, by thirty geographical miles. For the earth takes two minutes to revolve that distance.

The first mechanical device for measuring the daily lapse of time was the water-clock that was used by the Babylonians and Egyptians and other ancient nations around the Mediterranean. It consisted of a basin with a spout or tap from which water trickled into a receiving vessel. On the inside of the receiving vessel were marks from which the hours could be told by the height of the water. In the course of time this simple mechanism was greatly improved — especially by the Greeks. The receiving vessel became a long cylinder, in which a float was placed. Connected with the float was a chain passing over a pulley on a spindle, and balanced at the other end by a weight. To the pulley was fixed an hour-hand, which pointed out the hours on a dial, as the float rose on the water. The energy obtained from the rising water by means of a float or some other contrivance was sometimes used to work mechanical figures, instead of being employed to move an hour-hand over a dial. About eleven hundred years ago the king of Persia sent Charlemagne a water-clock of bronze, inlaid with gold, which was very ingeniously constructed.

The dial was composed of twelve small doors, representing the hours. Each door opened at the hour it represented, and out of it came a number of little balls, that fell one by one at equal intervals on a brass drum. The hour of the day was shown to the eye by the number of doors that were open, and the ear was informed of the time by the number of balls that fell. At twelve o'clock, a dozen miniature horsemen issued forth and closed all the doors. At the time when this Oriental marvel was still being displayed in France, King Alfred made a simple clock by which, at night-time, he could both write and tell the time. For it was simply a long, thick, slow-burning candle, with the hours that it took to burn marked upon it. The

KILAUEA VOLCANO, CONE NORTH OF HALEMAUMAU, HAWAII

Photo Neorihiro

The stream of viscous lava flowing from the crater forms blobs which cool first on the edges, pushing forward claws until they look like a mass of lobsters, — which indeed they are called — as shown in this picture loaned by Dr. T. A. Jaggor, Jr., Director of the Hawaiian Research Association.

The Earth

THIS great division of our work tells the story of the tiny planet on which we live, of its shaping and of the stuff of which it is made, and how it is still in flux, constantly changing; of its waters and buried resources; of the outlets of its central fires. Several "ologies" are involved, but the style in which they are stated is so clear that he who reads may understand and learn.

The Birth of the Earth

Where did the world come from?

Man a pygmy compared with the world he lives in, yet the latter is but a speck compared with the colossal masses with which space is strewn

All the World on Fire

How long has the Earth been spinning?

The crust of the Earth—how hard we know it is, how thick we guess it is, how old we think it is

The Earth's Ups and Downs

Sowing the dust of continents to be

The great upheaval in which mountains rose from the sea and ocean depths were formed
What "faults" are and how they occur

How the Old Earth Trembles

The marvels of the seismograph records

A great Japanese seismologist describes his invention
How earthquakes are foreseen and their effects mitigated

Earth's Autobiography

Life stories sealed up in past ages

The rocks as enthralling as a novel if we but know how to read them
Fossils of animals alive before man came

The Earth's Foundations

The things the world is made of

New knowledge of the elements and the amazing things that happen when they come together
The marvelous scales that will weigh one millionth of a grain of radium

Inside the Earth's Crust

A survey of the leading metals

How iron serves an immense variety of man's needs
A metal so rare that it would be worth $40,000,000 a pound

Metals that Seek a Mate

From the sea shell to Milan cathedrals

The part played by salt in the realities of health and fallacies of the superstitious
The importance and fixation of nitrogen

Elements not Metals

The invisible allies of progress

Hydrogen, the lightest gas known, a very widely distributed element
The element, silicon, of which one-quarter of the Earth's crust is composed

What Things are Made of

The secret of the infinitely small

What it is that makes the difference between solids, liquids and gases
What the tiny and nimble electrons can do

The Radioactive Elements

Breaking up the "foundation stones"

The epoch-making discovery of a French scientist and his Polish wife
The three different radiations that emanate from radium

The Mystery of Matter

The master-energy of the universe

Explosions in an atom of radium that go on giving heat for thousands of years
Theoretical difference between an ordinary atom and one of radioactive matter

The Air in Which We Live

An indispensable condition of life

What we should see in the sky if there were no atmosphere
Why twilight is long in June and December and short in March and September
Why we see the Sun after it has set

The Contents of the Air

The playground of electricity

Its elasticity, weight, humidity and useful dustiness
What mist is

Atmospheric Movements

Gales from the whirling Earth

What an approaching cyclone looks like—if you are foolish enough to stop to see
Places with similar heat through the year round the world

The Wonders of Water

Testing the different sea waters

Where it comes from, how it was made and why it varies in composition
Water as alchemist and architect

Romance of the Sea-Beds
The dark, unfathomed caves of ocean
Does the Pacific Ocean fill a huge rent from which the Moon was torn?
How little land would be left if the seas rose 2,000 feet

The Travel of the Waters
The tides and currents of the sea
Where the tide goes out for miles and leaves pasture-land
Fierce attack of a South American tidal wave

A Study of Sea Waves
Rain stronger than mighty waves
Waves not so high as they look to the sea-sick passenger
The serious problem of coast defense

Inland Water Reserves
Features of the world's great lakes
Past and present formation of lakes and marshes and their slow disappearance
Lakes big as seas and salter than the sea

The Return of the Waters
Distribution of the chief rivers
How the Atlantic Ocean receives more than its share of river water
A change of course sometimes alters the state a town lies in

Water Stores in Springs
The resurrection of the waters
Springs intermittent, submarine, fresh, hot, and mineral
How the Romans utilized a radium-tinctured well

Rivers as Sculptors
Mountains leveled to make new land
Streams above and below ground, what they destroy and what they build
At the rate of erosion of the Mississippi North America would be worn down to sea-level in 4½ million years

Problems of Cloudland
The battle between Earth and Sun
Dust the scaffolding upon which clouds are built
The place of clouds, always dropping, taken by clouds nearly formed

Rain as Friend and Foe
The red rain of superstition
Why it rains, how much it rains, and the queer things that rain can do
Sixty-seven feet of rain in a single year holds, one hopes, the world's record

The Solid Waters
Do the world's ice reserves lessen?
How icebergs break away from a glacier and go sailing away
What would happen if winter snows did not melt and disappear

Journeyings of the Ice
Glacial creepings now and long ago
How, as travelers and burden-bearers, engineers and engravers, glaciers tell the story of the past

The Weather Mystery
At the cooling point in the Earth's life
The hottest and driest place in the world
The important part humidity plays in the day's heat or cold

Mountain Storehouses
Effects on nature and the mind of man
The great ranges of all the continents and the solitary peaks
The most fertile lands in the world made of the wear and tear of mountains

The Making of Mountains
Cycles of decay and construction
How the average mind exaggerates their relative height and steepness
The wrinkles on the Earth's face change, as on man's, with time

Earth's Flattened Areas
Dust that collects yet defies rain
Vast seas of sand rippled and waved like the sea
Great deposits of salt and borax stretching away in a glistening desert

The Islands of the Main
How the Pacific Islands were formed
Atolls due to tiny coral polyps ceaseless industry
Deep straits where once islands were joined to the continent

The Great River Plunges
The wonders of stupendous cataracts
How the water comes down at Niagara, Victoria, Kaieteur and Iguassú
From "slow-dropping veils of thinnest lawn" to the mighty rush of thunderous volume

In the Bowels of the Earth
A dustless and germless underworld
The infinite variety of stalagmite and stalactite formations in caves
The largest known cave in the world

Geysers and Volcanoes
Was old ocean made by volcano steam?
The various vents through which the Earth's internal heat bursts steaming forth
The slumbrous giant who buried Roman cities in liquid lava and ashes

Volcanic Catastrophes
Scenes when fire rained from the sky
The volcano that is not a mountain but a cup-like depression in a great plain
What the 1923 earthquake did to Japan

THE EARTH'S FOUNDATIONS

New Knowledge of the Elements and the Amazing Things that Happen when They Come Together

THE THINGS THE WORLD IS MADE OF

IN discussing the making of the earth we have seen that certain substances known as "elements" enter into the composition of its crust, but so far, we have not considered what we mean by element. By element we mean a simple, pure substance that by no known means has as yet been divided into parts with different properties. For instance, if we take the red substance known as mercuric oxide, and grind it into a powder, each grain still remains mercuric oxide; there is no difference between one grain and another. Is mercuric oxide therefore an element? Perhaps!

But we have not yet done our disruptive worst. Let us try the ordeal by fire. Let us heat it. When we do this we find that it is shaken to pieces, and that it divides into a heavy vapor which condenses as the liquid metal mercury and the gas oxygen, which supports combustion. Mercuric oxide, therefore, is not an element; it is a compound of two substances which it is possible to separate. But when we take the two separated substances we may roast them, and freeze them, and electrify them, and do what we will with them — they still remain mercury and oxygen, a liquid metal and a gas, each with certain fixed, definite qualities. We say, therefore, that oxygen and mercury, as far as we know, are elements.

Or, to take another instance, we get some tallow and divide it into small pieces. Each piece still remains tallow. We melt it, and it solidifies as tallow. We freeze it, and it thaws as tallow. Is tallow, then, an element? No, we must experiment further. Let us burn the tallow as a candle.

Lo! the tallow is now torn all to pieces. A black substance, carbon, separates out of the tallow, goes off with the oxygen in the air, and with it forms a gas called carbon dioxide; and a gas called hydrogen likewise comes forth from the burning tallow, links arms with the oxygen in the air, and goes off as water. So tallow is certainly not an element, but a very complicated compound, composed of several elements.

Or take water. We can heat water into steam, or freeze it into ice; yet it retains its chemical qualities as water, and gives rise to no substance with other than aqueous characters. And yet water is not an element either, for by passing it over red-hot iron or red-hot carbon, or by passing a galvanic current through it, water can be divided into two gases, oxygen and hydrogen, both of which are quite dry, and neither of which is in the least like the water which the two together form. Even a little piece of potassium laid on water will break up the water, keeping for itself all the oxygen and part of the hydrogen and liberating the rest of the hydrogen which will burn on account of the heat evolved by the chemical action. So water, in spite of all first appearances to the contrary, is not an element after all.

Only after a substance has resisted the most violent and ingenious efforts to pull it to pieces do chemists call any substance, whether gas, or solid, or liquid, an element. Even then it is better to be guarded, for chemists have frequently found out that substances which seem simple are really compound, and can be divided into parts chemically distinct.

For years and years, for example, caustic potash was considered an element till the chemist Sir Humphry Davy succeeded in shaking it asunder by electrolysis, and showed that it was really a compound, and that an unknown metal — now known as potassium — could be separated from it. Like most discoveries, this discovery led to more, and Sir Humphry soon broke up some other substances; he thus discovered the new element sodium and was the first to isolate strontium from its compounds and to prove that chlorine and magnesium were chemical elements. Since Sir Humphry Davy's day many new elements have been discovered, and there are now about eighty. Some of these were difficult to find because they were tightly combined in compounds. Some, like the inert gases in the air — neon, xenon, argon, krypton and helium — escaped notice because they occur in very small amounts, and have no chemical activity. None of these five atmospheric gases combine with other gases; they lead lazy lives, and do nothing to attract attention.

The little known elements, and the light given off by solid bodies

About half the elements are well known, and about half are hardly known at all. We have all heard of aluminum, antimony, arsenic, bismuth, calcium, carbon, chlorine, cobalt, copper, gold, hydrogen, iodine, iron, lead, lithium, magnesium, mercury, nickel, nitrogen, oxygen, phosphorus, platinum, potassium, radium, silicon, silver, sodium, sulphur, tin, and zinc. But how many people have heard of columbium or niobium, erbium, gadolinium, indium, lanthanum, neodymium, praseodymium, rhodium, samarium, terbium, thulium, ytterbium, yttrium, zirconium or europium?

Some of the rare elements have been detected in a most wonderful and interesting way by spectrum analysis. It is well known that the white light of the sun is really a mixture of colored waves of light, and that the colored waves can be separated from each other by passing the white light through a prism. All solid bodies, if heated to what is called white heat, give off similar composite white light that can be analyzed into component colored waves. But it is found that when any substance is raised to a state of vapor and rendered incandescent it no longer gives off white light, but certain characteristic colored rays which can be analyzed by a prism, and serve to distinguish the given substance from all other substances. Sometimes the colored rays can be discerned by the eye, and the colored lights of fireworks are easy objects for this rough eye-analysis.

The analyst who finds the 180-millionth part of a grain

The scientific instrument for the analysis of the light of incandescent vapors by means of a prism is called a "spectroscope," and the analysis "spectrum analysis."

By vaporizing many substances at a moderately high heat and analyzing their light, the most minute traces of certain elements may be detected. For instance, one 180-millionth part of a grain of sodium, one 6-millionth part of a grain of lithium, one millionth part of a grain of strontium and calcium can be detected. In view of the wonderful delicacy of this mode of analysis, it is not strange that it led to the discovery of some of the rarer elements. In 1860 Professor Bunsen was making a spectroscopic examination of the deposit left after the evaporation of the Dürkheim springs in Germany, and he noticed some bright lines he had never seen before. Taking the hint, the professor was led to search for new elements, and succeeded in finding cæsium and rubidium.

The instrument which identifies salt burning in the kitchen or in the sun

In 1862 Sir William Crookes discovered another new element which gives a magnificent bright green line through the spectroscope, which he therefore christened thallium, from *thallus*, the Latin word meaning a green twig. Two years later two indigo-colored lines betrayed another element to two German professors, who straightway isolated it and called it indium, because of its indigo light. Finally, in 1875, two violet lines led to the discovery of another new metal which its discoverer named gallium.

Within the plain is a deep, fiery pit called Halemaumau whose surface of varying area melts and solidifies, rises and falls. This pit is sometimes filled with heaving lava, boiling from the escape of gases, and sometimes empty to a depth of 1000 feet. Frequently when the pit mass is thoroughly melted, red- and white-hot lava jets 10 to 50 feet high are thrown from its surface. Kilauea's first recorded eruption was in 1789 and consisted chiefly of cinders and sand. But in 1840 it discharged a flood of lava from one to three miles wide and from 12 to 200 feet deep. It flowed 30 miles in four days and leaped as a cataract a mile wide into the sea. For three weeks this "Mississippi of molten material" rushed through deep valleys into the sea, which boiled and steamed where the river of fire entered it. For twenty miles along the coast the waters were hot and the lurid glow of the flowing lava could be detected at night by ships 100 miles away. So we rightly say that Mauna Loa with its double crown of Mokuaweoweo and Kilauea surely deserves the title of "King of Volcanoes".

The earth is by no means so solid and so stolid as it seems. Its crust may be cold, but its heart is prodigiously hot. From the time when its molten waves surged beneath the sun it has never been quite *terra firma.* Tremendous, massive changes in the contours of its land and water have continually occurred. Mountains have sunk and risen, seas have waxed and waned, whole continents have appeared and disappeared. Even now the Andes and Scandinavia and Scotland and most of the coral islands seem to be slowly rising, and other parts of the world seem to be slowly subsiding.

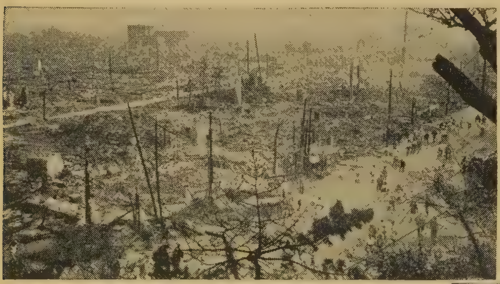
But apart from these great, slow, massive see-saw movements, the crust of the earth is subject to more or less sudden vibrations, quiverings, quakings. Constantly the earth is jarred, and jolted, and tugged; twice a day not only its

Photo from Wide World Photos

THE 1923 EARTHQUAKE IN JAPAN

This scene of devastation marks the site of the Fuji Cotton Spinning Mills at Koyama, south of Tokio, where hundreds of operatives were trapped under the mass of brick and iron of the falling walls and roof.

waters but its continents and mighty cities are lifted and let fall by the moon; and no doubt the crust responds to changes of atmospheric pressure, and to the pounding of the tides. The more noticeable wave motions in the earth's crust are termed earthquakes, and we might expect some of these as a result of violent volcanic eruption. Such, in fact, is the case, but these movements are slight and much restricted in area. Still it is popularly believed that volcanic eruptions and great earthquakes are directly connected. This supposed connection was first disproved in Japan by the work of Milne, the English pioneer seismologist. Omori, the greatest authority in this matter, recently deceased, remarked that "a volcanic district may be assumed to be free from the visitation of a great destructive earthquake whose area is extensive and whose intensity is sufficient to destroy properly constructed wood or iron buildings." The subject of earthquakes is elaborately treated in another section, but we may, without repetition, note briefly some of the great quakes of modern times. In 1887 there was a very violent shock in northern Mexico, extending through most of New Mexico and Arizona, and in 1899 southern Alaska was badly shaken, but as both of these districts were thinly settled the loss of life and damage were very slight. In 1906 central California suffered, and especially San Francisco, when 1000 lives were lost and much property was destroyed by fire following the shock. In 1907 Kingston, Jamaica, was partially wrecked, and there were many changes in its coast line and harbor. In 1908, Messina and Reggio, two cities on the narrow strait that separates Sicily from the mainland, were completely destroyed with 100,000 direct victims of the earthquake. The most extensive quake ever reported was that of Assam, India, in 1897, destructive over 150,000 square miles and distinctly felt over an area of 1,750,000 square miles. In intensity, however, and in vital and financial loss the Japanese quake of September 1, 1923, exceeds all the others. The first reports from the scene of disaster were much exaggerated, but official figures given two months later show the magnitude of the catastrophe. The total area affected by the quake, the subsequent sea wave and fire was about 9000 square miles. The population in this area was nearly 8,500,000; and of these 200,000 were killed, 250,000 reported missing and injured and 2,000,000 rendered homeless, mainly in Tokyo and Yokohama. Scarcely any undersea changes have been detected in Tokyo Bay and very little surface change in the shaken area.


BUSINESS CENTER, TOKYO


THE AFTERMATH AT YOKOHAMA


Photos from Wide World Photos
THOUSANDS BURNT AT HONJYO, TOKYO

INSIDE THE EARTH'S CRUST

The Metals with which Man has Hacked and Blazed His Way through the Dark Jungles of Barbarism

A SURVEY OF THE LEADING METALS

WE have mentioned the substances that play the chief part in the constitution of the crust of the earth; but the earth's crust is full of a number of things that play other parts than mere crust-making, and are of particular interest to the living beings inhabiting the crust. Chief among these interesting things are the metals. So important are metals to civilized man that some are used as milestones and landmarks of progress, and it is common to talk of the Stone Age, the Bronze Age and the Iron Age. With metals, indeed, has man hacked and blazed his way through the dark jungles of barbarism.

What is a metal? The term is too ancient to be scientific, and, though science uses it, science has not succeeded in giving it a very sharp and distinct definition. But certain substances are put in one class and called "metals," because they have certain characteristics more or less in common. They are lustrous; they are good conductors of heat and electricity; they are usually rigid when cold, yet show a certain amount of elasticity. Most are opaque to light; but gold, if beaten out into very thin leaves, transmits green light, and thin films of mercury transmit light of a violet-blue color. Probably all are capable of assuming a crystalline structure, and some, such as zinc, show crystals quite clearly.

But perhaps the features that nearly induce and best justify the classification of metals are the properties of plasticity, malleability and ductility, which have rendered certain substances so useful.

The plasticity of metals, their capacity for being molded as a potter molds a bowl, varies in individual metals and depends on circumstances. Thus, potassium and sodium, even when cold, can be worked with the fingers like wax, and lead and thallium are also easily molded at ordinary temperatures. Others, such as zinc, iron and lead, become readily plastic only when heated. Even those hard metals which seem to lack plasticity are, however, really quite plastic, as was shown in quite a sensational way by H. E. Tresca (1814–1885), who drilled a cylindrical cavity in a block of steel and made a hole in the bottom of the cavity that reached to the exterior of the block. He then put little discs of metal into the cavity, and by means of a piston working under hydraulic pressure he subjected the discs to a pressure of over 200,000 pounds. Under this pressure even such a hard metal as iron was squeezed like putty through the hole in the bottom of the cylinder.

In some metals the malleability, or the capacity for being flattened into thin sheets by hammering or pressure, and ductility, or the capacity for being drawn out into wire without breaking, are most remarkable. Gold-leaf, for instance, can be beaten out till it is only a 280,000th part of an inch thick. A single grain of gold has been pounded out so as to have a surface of nearly 80 square inches, and platinum can be drawn out into a wire so fine that it would take 800,000,000 strands to make a cable one inch in diameter.

Metals vary in color: many are white or gray; but gold is yellow, and copper is reddish. Metals also vary in weight. Potassium, lithium and sodium are light enough to float on water. Silver, on the other hand, is more than ten times the weight of water, and platinum and osmium are more than twice the weight of silver. Each metal has its own characteristic melting-point. Thus mercury is solid only at very low temperatures and melts — or returns to its normal liquid state — when its temperature is allowed to rise to $-39°$ C. Potassium and sodium melt below the temperature of boiling water. Silver and gold melt at a temperature of 961° and 1063° C. respectively. Platinum requires a

IRON AS IT IS BROUGHT OUT OF THE EARTH

temperature of 1755° C. Tungsten melts at about 3000° C., the highest of any known metal.

The most important metals which are used in metallic form are iron, aluminum, copper, zinc, lead, tin, mercury, silver, gold and platinum. There are also many rare metals which have interesting special uses. Metals which occur chiefly in combined form will be discussed elsewhere.

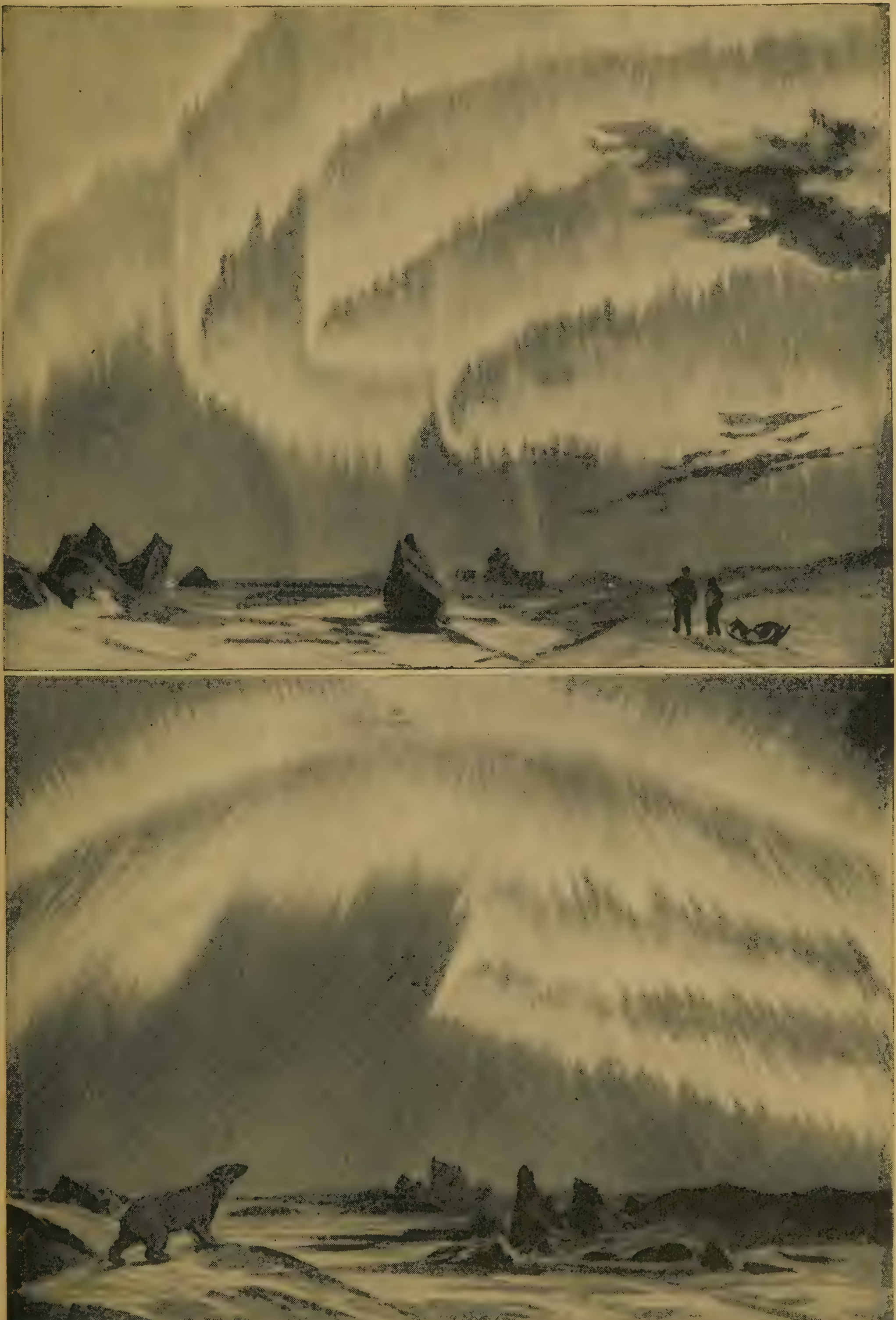
It must not be thought that all the metals occur in a pure state in the crust of the earth. A few, such as gold and platinum, are found practically pure, but most of them are oxidized and mixed with foreign material, forming ore from which they must be extracted by various processes. We need not here discuss the metals individually, but the more interesting and important may be considered. And first must come iron.

The Iron Age began in different countries at different times. In Egypt, Chaldæa, Assyria, China, iron was used nearly six thousand years ago. In Etruria iron was known about 1400 B.C., and in Gaul about six hundred years later. According to the poems of Homer the ancient Greeks used iron about 1200 B.C. In England the Iron Age began later still, but iron was worked by the ancient Britons before the invasion of Julius Cæsar. In Russia the Iron Age began only 1100 years ago.

The term "Iron Age" has a really deep significance; iron is the material foundation of the world's mechanical energies — its Atlantic liners, its airplanes, its automobiles and all its multifarious machinery. The great iron-masters are and must be the great world-masters; iron, cleared of dross and mixed with brains, is the great lever of the world.

Without iron, civilization would be hardly possible. It owes its paramount importance to its unique versatility and adaptability — a versatility and adaptability rivaled by no other substance. Razors, nails, battleships, watch-springs, horse-shoes, bridges, darning-needles, files, hand-cuffs, pokers, skyscrapers and a thousand other manufactured articles, testify to its divers uses. And the spear may readily be made a pruning-hook, and the sword may readily be beaten into a plowshare. It can be made hard or soft, strong or weak, brittle or plastic, fusible or infusible. The blacksmith in some countries tests the iron nails for his horse-shoes by bending them on his forehead, and yet iron projectiles can be made hard enough to pierce the thick armor of battleships, or smash hard ore, as one might sugar with a hammer.

Strangely enough, the qualities of iron depend largely on the amount of foreign matter it contains and chiefly on the amount of carbon it holds, and all the resources of metallurgy have been devoted to combining the iron and carbon in right proportions. Iron is, of course, indispensable as the medium of mechanical activity, but it performs other functions in the world that must not be forgotten. Owing to its ductility and plasticity it forms a most serviceable medium for art.



THE AURORA BOREALIS, THE BEAUTIFUL NORTHERN LIGHTS MADE VISIBLE BY THE PRESENCE OF DUST IN THE ATMOSPHERE

primary types of air-pressure outlines, and five secondary shapes. It is these secondary shapes that generally give the forecaster most trouble.

In V-shaped depressions violent shifts of wind and sudden changes of temperature usually occur. And they are accompanied by heavy squalls, with showers of rain and hail, or winter's snow. They are the birthplace of many thunderstorms, as also are the secondary depressions. Very slight differences in the curves of these outlines of low pressure are sometimes indicative of abrupt weather changes. And the considerable progress that is being now made in forecasting seems to depend on subtle interpretation of almost unnoticeable variations in the lines plotted out, in hundredths of an inch, on barometer charts. And here there tells also the information as to the force and direction of the wind, and the temperature and the state of the sky, which the forecaster receives from each observing station.

In Europe and in the United States a large amount of work has been done in the line of determining the conditions of the upper air by means of recording instruments which are sent up attached to kites and by means of small pilot balloons whose movements through the air are determined with theodolites. By long series of such observations a fairly accurate knowledge of the effect of the upper air conditions on the weather has been obtained, and this knowledge is of great assistance in foretelling the weather.

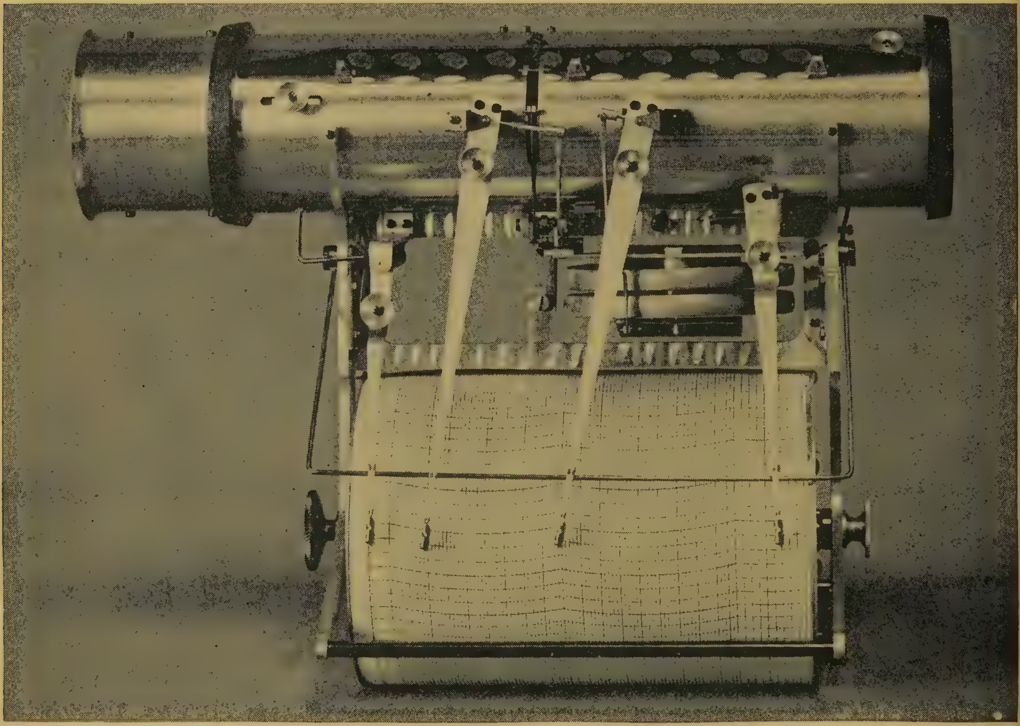


Photo U. S. Weather Bureau

A KITE-RAISED WEATHER RECORDER

This instrument, called a meteorograph, records the wind velocity, air pressure, temperature and humidity of the upper regions of the atmosphere.

Undoubtedly an element of instability and incalculability will forever remain in weather forecasting. But though the science of charting observations is scarcely more than sixty years old, there is now a fair promise that man will obtain a very useful amount of foreknowledge of weather conditions. Already men in many kinds of business rely on the Weather Bureau for information by which they guide their actions. For they have found the forecaster is so often correct that large sums of money are saved every year by trusting to his report.

WHERE THE SUN SHINES AT NIGHT AS WELL AS BY DAY

THE MIDNIGHT SUN OVER THE GLOCKENSUND

Industry

IN this great division of our book are recorded some of the more important ways to which man has applied the power he has wrested from Nature. Here we meet the great industrial armies of the world, inventing, discovering, creating, making the world anew. It tells of the triumphs of man's labor under the ever-advancing guidance of science. It is an inspiring record of progress of which the end is not yet.

Life in the Great Oil Fields

The mineral of the modern world

Releasing from the depths of the Earth the pent-up energy of ages

A vast business still only at its beginning

The Cotton of the World

The source of the South's prosperity

The vegetable fiber that gives work to millions and clothes to all

A tiny ball that makes a thread 100 miles long

The Story of Steel

One of America's basic industries

From ore to finished product

The material for the skeleton of this workaday world

The World's Black Diamonds

Coal, the buried treasure of nations

The stored sunshine of the ancient world gives up its heat

The source of modern power of which the ancient world knew nothing

Building an Automobile

The age of the horseless carriage

Why nobody can afford to walk

Mass production, progressive assembly, spectacular features of modern factory

The World's Great Canals

Inland cities transformed to seaports

Logical means of transport we are only beginning to use

Why break bulk at the seaboard?

Building the Iron Horse

How modern locomotives are constructed

From the tiny "Puffing Billy" of 1813 to the Virginian "802" of 1923

Giants that heavy trains and steep grades do not daunt

From Cave to Skyscraper

The wonder of reinforced concrete

High buildings the economic outcome of high real estate values

Ocean to Ocean Railways

Connecting the Atlantic and the Pacific

The modern representative of the covered wagon

East and West made one by rail

Spanning the Waters

Some of the world's great bridges

The widest river, the deepest gulch no longer a traffic obstacle

Marvels of suspension, wonders of cantilever types

The Romance of Rubber

How the world's supply has increased

Tapping tropical trees for tubes and tires

The milky fluid that flows purest from high up the *hevea* stems

The Symbols of Wealth

Searching for nature's buried treasure

What we all want and few get

Gold and diamonds and how they are mined

Price of diamonds a sign of a country's prosperity

The Keeper of Knowledge

An industry that preserves learning

How the newspapers eat up our forests

Processes by which rags and grass are beaten and made into paper

Toilers Beneath the Sea

Methods that save from disaster

What divers things men find when they go down into the sea

How divers breathe, see and hear at great depths

The Sugar Industry

How cane and beet are grown and treated

Satisfying the craving of everybody's "sweet tooth"

Filling the sugar bowl on your table

Where our Salt Comes from

The industry that led to commerce

Its agreeable savor and preservative value

What salt nowadays too often lacks

The Harvest of the Sea
The development of a primitive industry

Where the fish dealers' supplies come from and how they are taken

How the "iron chink" has replaced the living Chink

The Canning Industry
The machinery used in food preservation

How the season no longer limits human diet

Tempting tins that make for easy housekeeping put up under ideal conditions

The Building of a Ship
The conquest of the watery wastes

From Columbus' caravel to the greyhound of the North Atlantic

Strength, size, speed, luxury multiplied in ocean travel

The Making of a Newspaper
Telling to-day's happenings to-day

How what costs a small fortune can be bought for a nickel

The army of men who bring the world's news to your breakfast table

How Buttons are Made
The story of vegetable ivory and mussel

Man presses the button, they do the rest

From tree to trouser, from shell to shirt

The Sewing Machine
Its early history and recent development

A complete factory equipment in every home

An American invention known the world around

Harnessing the Oyster
The culture-pearl industry of Japan

How a shell fish's stomach-ache results in a gem

Artificially caused inflammation, and its pleasing results

Art out of Chaos
Pottery, the world's oldest industry

How your plates and cups and saucers are made

Vases that stored food before the Christian era

The Dairy Industries
Science in making butter and cheese

Primitive methods, dirty hands, replaced by immaculate machines

Infant mortality reduced by science

Making the Desert Bloom
Attempts to supply the lack of rain

Marvels of modern long-distance irrigation

What water, properly applied, will do for agriculture

A City's Water Supply
Modern solution of an ancient problem

The long journey from spring to faucet and how it is "routed"

Roads and Road-Making
The dustless roads of the future

Why the motorist is so often tempted to exceed the speed limit

Concrete versus tarvia, macadam versus dirt

Science and Shoemaking
Rise of the American boot and shoe trade

The hide from distant pampas treads London streets

Where machinery rivals hand work and beats it in cost

Evolution of the Typewriter
Speeding up business correspondence

How shorthand has replaced long-hand writing

The machine that every office has to have

Furs and the Fur Trade
How fur farming has become a science

Where milady gets her latest neckpiece

Why wild fur-bearing animals are so scarce and prices so high

The Marvels of Glass-making
How industry gives eyes to science

Even bottles are now made by a machine

How great store windows of plate glass are made

Tobacco Manufacture
Marvelous growth of the cigarette industry

How they keep "the holy and divine weed" from cross-fertilization

Making cigars and cigarettes by the million

The Forest Industries
The romance of the woodman's life

Scientific conservation and reforestation imperative

Fire dangers and how they are guarded against

Treasures of the Quarry
Strength from Earth's central fires

Stone for a Phidias's art or a city's buildings

Blasting the everlasting hills

Keeping Mankind Warm
How wool is used for man's protection

Growth of what is doubtless the world's oldest industry

How what once covered the sheep now covers you

The Silk Industries
The strife of silk-farmer and chemist

Even the worm no longer able to compete with the laboratory

HOW COLD CONQUERS DECAY

Man's Constant Battle with Microbes for the Preservation of his Daily Food

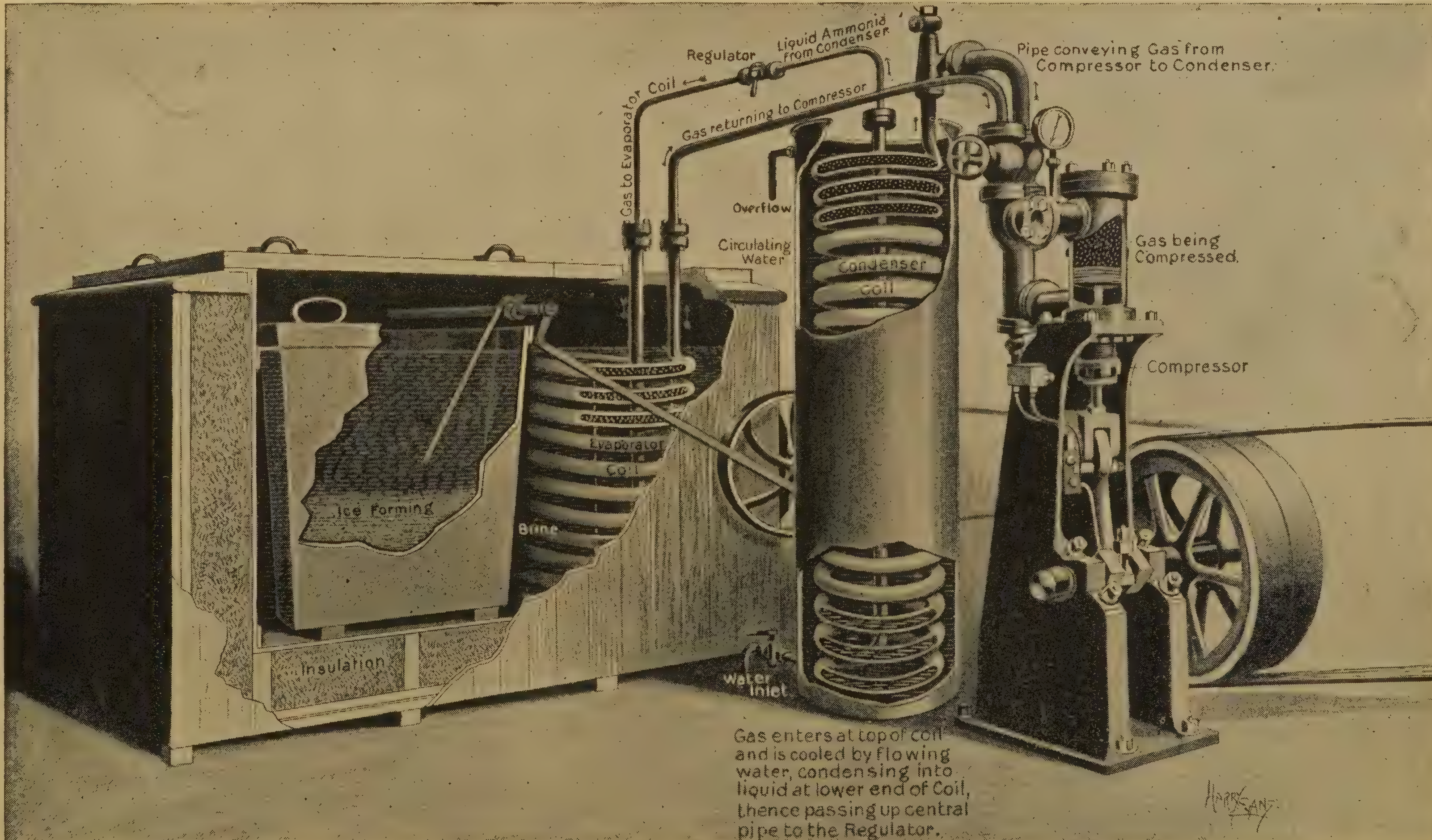
THE TRIUMPH OF REFRIGERATION

IT is doubtful if anything has affected the economic conditions of our country in recent times so much as the discovery of means of preventing the decay of foodstuffs. Next to the railway and the steamship, the refrigerator has perhaps done more than any other modern invention to benefit our vast industrial population. Indeed, without the new methods of sterilizing, chilling and preserving meat, butter, fruit, vegetables, fish, milk, eggs, that are now practised, our cities could not properly be fed. Extreme fluctuations in the supply and price of the principal provisions would be frequent, and a large number of the poorer classes would be subject to recurring periods of misery. But on the foundation of a few simple inventions a magnificent industry has now been built, by means of which foods produced in localities where there are insufficient people to consume them are carried and delivered in a fresh condition to hungry and overcrowded cities, or delicacies that will grow in one climate are preserved for the enjoyment of less fortunate lands.

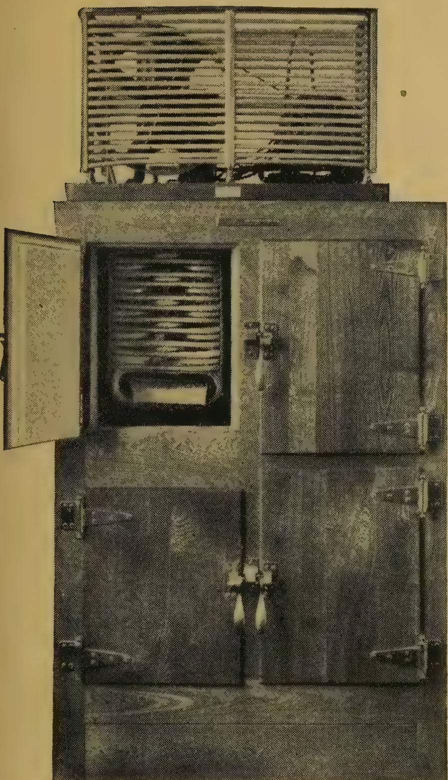
And all this is the result of an easily won victory over the germs of decay. The microbe is a useful scavenger. But for its incessant and universal action our earth would be buried in the ruins of life. Everything that died would rest on the ground, encumbering and stifling all the younger growth of our planet. Forests would be but a mass of fallen trees, through which no young, green shoot could pierce. Fields would be blanketed with dry, withered grasses and dead plants; and even the flesh of the mammoth of the great Ice Age would not have perished yet from off its bones. It is the microbes that clear all the dead growth from the earth, and keep a large, clear path for succeeding generations of plants and animals. It would be disastrous to interfere on a large scale with the work that they are doing, but from the earliest dawn of civilization man has been compelled to fight them continually for the preservation of his food supplies. Every time that he has tried to store the abundance of one season against the need of a time of scarcity, he has had to fight against the innumerable germs of decay that fill the air with their invisible armies, and occupy all the seas and lands between the ice-bound region of the poles.

So, from the earliest ages, the hunting savage has dried and smoked and salted his meat and fish. Pastoral races have found a way of preserving the milk of their cattle by making it into butter and cheese; farmers have discovered a means of preventing their grain from rotting by keeping it from becoming moist; and housewives have learned to pickle certain vegetables, and make sugary syrups to conserve fruits. Drying is the most natural and oldest process of preservation. In nature, the germs of seeds and nuts are protected from the agents of decay by their dryness. The microbes that bring about decomposition are a very low kind of plant and, like all vegetable life, they need moisture to grow and multiply. So by drying meat the Boers make their biltong, and the Indians their pemmican. And several great modern industries use the drying process in making extracts of meat and preparations of evaporated milk, which can be kept for a long time.

MAN'S MECHANISM FOR DOING THE ICE-WORK WHICH WINTER CAN DO SILENTLY IN A NIGHT



This picture-diagram shows the principle of the refrigerating machine, as applied to the manufacture of ice, the object being to cool brine, by the evaporation of liquid ammonia in coiled pipes, sufficiently to freeze the fresh water in a can submerged in the brine.



ISKO ELECTRIC REFRIGERATING UNIT INSTALLED ON JEWETT ICE BOX

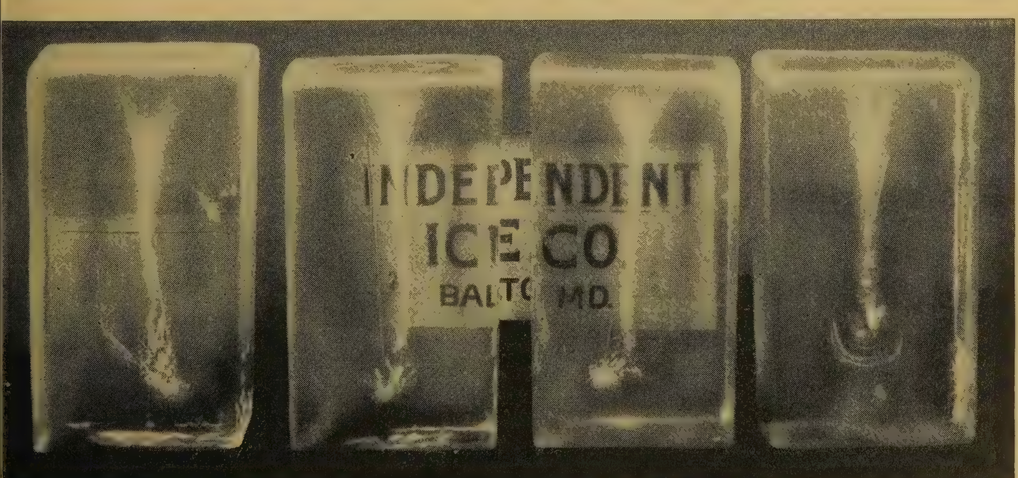
An SO_2 domestic machine driven by an electric motor. Air cooled condenser built around compressor which carries fan to circulate air.

Bacteriological statistics show that the ordinary "ice-box" is a breeding ground for millions of germs, due to the dampness of the melting ice and to the fact that the temperature runs from 50° to 70° F. On the other hand, refrigerators cooled with refrigerating machines can be constantly maintained at a temperature of 35° to 40°. The breeding of disease germs is checked by this low temperature and by the total absence of sloppy, unsanitary ice.

An idea of the space occupied by different refrigerants is given in the following table, which shows the approximate volume in cubic feet of one pound of substance at different temperatures.

Refrigerant	0° F.	32° F.	35° F.	40° F.
Water (Steam)		3296.	2941.	2441.
Ammonia . .	8.19	4.631	4.364	3.959
Sulphur dioxide . .	7.54	3.65	3.43	3.10
Carbon dioxide . .	.284	.166	.160	.136

If each refrigerant absorbed the same quantity of heat during evaporation it would follow, for example, that the volume of water vapor would be about seven hundred times that of ammonia vapor for a given amount of refrigeration, but as water absorbs about twice as much heat as does ammonia, it follows that only about three hundred and fifty times as much volume of water vapor must be handled as ammonia vapor. This explains why water was not used for so many years because the capacity of the piston type of compressor had to be made so great as to be mechanically unfeasible. In recent years it has been found possible to handle large volumes of steam with rotary compressors and with steam ejector-compressors with comparative ease, so that one of the most recent developments in mechanical refrigeration again embodies the use of water as the refrigerating agent.



Courtesy De La Vergne Machine Co.

RAW WATER ICE

Kansas City. It takes a good polish and has been used lately in interior decoration. Minnesota limestones are usually yellow or yellowish brown, of fine grain, and have an excellent reputation. The best ones are quarried near Mankata and Kasota, in the south-central portion of the state.

Marble, the purest form of limestone and the most beautiful of all rock structures, is a limestone that has been acted on by fire, through the presence in its neighborhood of the molten matter that forms igneous rock. The effect has been to render the limestone crystalline, with a beautiful, fine,

Courtesy Vermont Marble Co.

WORKING A THIN BUT VALUABLE LAYER

TREASURES OF THE QUARRY

The Building and Paving Materials Sent into the Cities by the Stone-Workers of the World

STRENGTH FROM EARTH'S CENTRAL FIRES

THE quarrying of stone is, next to agriculture, the most universal of the great industries. Leaving out coal — a form specialized by its composition, uses and the depths at which it is worked — the getting out and shaping stone is a large part of man's work in almost every quarter of the civilized world.

Nearly every country and district has its building stone, although there are lands of sand, gravel, mud and dust where but few are used, and yet a sort of civilization has long existed. It is so, for instance, in the wastes of Yarkand and the ancient cities of Mesopotamia, but in the latter country the sun has almost made brick a natural product.

There are, too, lands where timber supersedes stone for many purposes, as on the great plains of Russia and the prairies of the West. But, allowing for these formidable exceptions, the range of the quarryman is remarkably extensive. Not many countries can be named where all the principal kinds of stone cannot be found, hard or soft, smooth or grained.

Though stone is heavy and unwieldy, it is valuable enough to be carried to and from all parts of a country, according to its qualities in use or beauty. Where are Massachusetts, Vermont and Rhode Island granites not carried? Who does not know the oölitic limestones of Bedford, Indiana, the slates of Vermont, the sandstones of Ohio, the marbles of Vermont, Tennessee and Alabama? And all these stones are repeated in many parts of the United States and other countries of the world. Such stones are not only used in the regions where they are found, but they are exchanged wherever carriage is feasible.

"Where are you sending these stones?" was asked of the owner of a quarry in Derbyshire, England, who was having fine sandstones shaped and dressed by machinery. In reply, the stone merchant took two invoices from his pocket, showing that one of the stones was going to Trondheim, in Norway, and the other to Nova Scotia, — long journeys over land and sea for such heavy and unwieldy cargo, but quite characteristic of the value put on stone suitable for special uses. The use in the case of these machined millstones was the pulping of wood for paper-making. Such an illustration of the removal, for thousands of miles, of the stones of the earth suggests a new view of quarrying.

What wonder if the instinct that led man to make his first weapons of stone has led him, later, to use the stone of his neighborhood, or maybe stone from afar, for his own shelter, security and eventually for his artistic delight?

The chief uses of stone suggest the universality of its working. It is needed for a very wide range of man's activities, beginning early in his civilization and going on late. Building himself a shelter with the loose stones of the rocky wild would be an early advance on seeking refuge from the weather in a cave. In this way the man could choose his place of residence, instead of depending on the chances of the atmosphere and water in making caves. The stone-built house is common to all lands where stone abounds. Indeed, it has been argued, with some degree of truth, that the original style of architecture of each country is dependent on the kind of stone found there.

This shaping power of stone, of course, is modified, in later times, by competition with wood, which, as civilization advances, readily supersedes the heavier material if both are at hand. In Norway, for instance, where there is an equal abundance of wood and stone, wood is preferred, for it is more readily handled, and costs less for carriage and for shaping. As buildings grow in size, substantiality and need for endurance, however, stone resumes its precedence, and, even in the most modern structures, continues to play an important part wherever dignity is considered.

A humbler main use of the earth's rocks is devised in the splintering of them into fragments of various sizes for the making of roads, from the solid pavement of regular Belgian blocks in cities with a heavy traffic, to the clean garden path of the suburban villa strewn with minute "chips".

Then, again, there is the utilization of the fine grit of some kinds of stone for grinding purposes — sharpening the edge of the more resistant metals till they become keen cutting tools. So home, industry, travel and art are spheres to which the quarryman's rough labors eventually find their way.

BLOCK WEIGHING 2738 TONS DISLODGED BY A BLAST OF 110 POUNDS OF BLACK POWDER

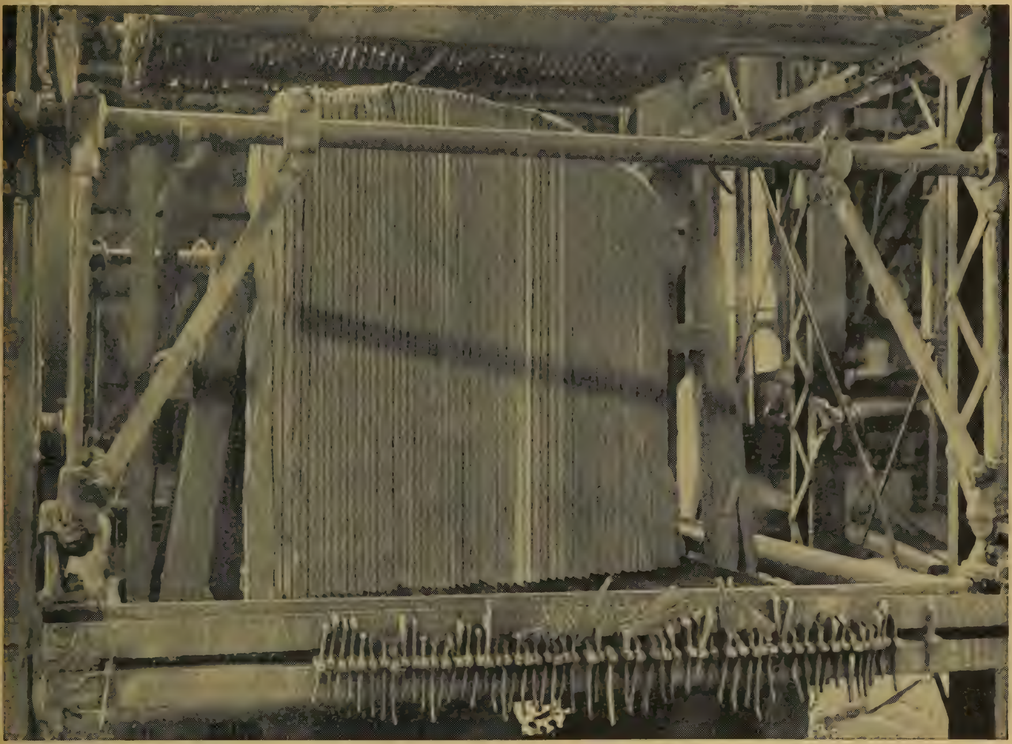
Where other materials than stone, for instance brick, or the modern steel skeleton, are used for the chief bulk of buildings, it is a common practice to rely on stone for the architectural ornament, for facings, linings, halls, floors and pillars when an effect of richness is desired, for certain kinds of stone, like the marbles, granites and sandstones are the natural material for art. The leap from the rough rock-built cabin to the statuary of Phidias wrought in Parian marble is a long one indeed, wide almost as the range of man's intellectual progress, but it is all within the limits of the story of stone.

The rocks that can be put to these varied uses are necessarily of widely different characters and origins, and some idea of the geological basis of the stone trade is necessary before we can appreciate the position of the granite rocks, sandstones, limestones, slates and marbles to which more extended reference must now be made.

Stone divides itself, geologically, into two main groups, first the rocks that have solidified from a molten mass — the igneous group; and, second, rocks that have been formed at later periods from the breaking up of the igneous rocks, the depositing of

along the fringe of the blue Italian sea, note that the mountains which have long been jaggedly cutting the eastern sky have become scarred with yellowy patches, almost from base to summit. These are the four hundred quarries of Carrara and Massa; and when Avenza is reached the train is beset by brown-skinned Italians who would fain load the passengers with tile-like slabs of beautifully polished marble. Here a little to the right is the tiny port of Marina, to which the products of the distant quarries on the hills are sent down, for conveyance to all the world. In one way or another seven thousand men are working in these quarries or conveying their spoils to the lazy railway and lazier sea. Considerably more than two and a half million dollars' worth of the beautiful creamy stone is brought down here yearly, a value much increased before its destinations in other lands are reached.

The marble industry of Carrara is a rather elaborate example of division of labor. One set of men gets the marble from its solid bed in the hills, and roughly squares the blocks; another set lets it carefully down the steep, rocky slope of the hills, on wooden sledges, steadying the sledges with ropes passed round posts by the side of the rough track; and then, at the bottom of the slope, the blocks are loaded by a third set on to ox-trucks, powerfully braked, and so are slowly taken, with much abuse of the imperturbable oxen, to the railroad and the sea, ten or a dozen miles away from the upper quarries.



Courtesy *The Travelers Standard*

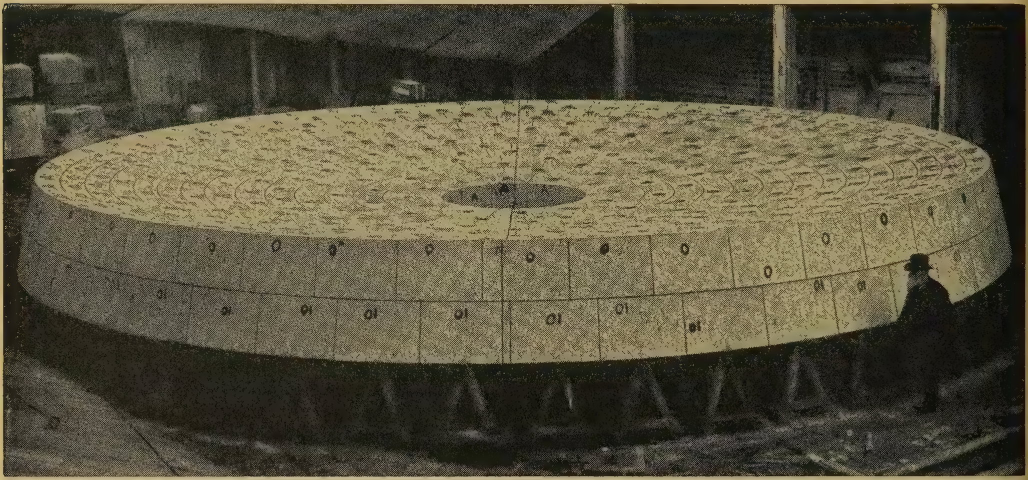
GANG SAW FOR SAWING MARBLE BLOCKS INTO SLABS

The marble is quarried by blasting with dynamite, a high degree of skill having been reached in so arranging the shots as not to break up the stone unnecessarily. The marble so procured is the raw material for a perfect hive of more or less artistic workers in the towns below. Practically all great sculpture from the time of Michelangelo has been chiseled from stone brought down from these inexhaustible quarries. It is only by seeing quarries like those of Carrara that one can realize how cathedrals like Milan could be built.

Several well-known granites are quarried in Massachusetts. At Milford there is a pink variety, and the quarries of this town supplied eighty-four 31-foot sectional columns for the Pennsylvania Railroad station in New York City. Gray and green granites come from Rockport, whence they are transported by water to the cities of the Atlantic seaboard. Quincy granite is noted for the high polish it will take, and has found wide use as a monumental and ornamental stone.

With a few exceptions, such as those of Hallowell and North Jay, the Maine granite quarries are located along the seaboard. General Grant's tomb, on Riverside Drive in New York City, was built of "white granite" from North Jay.

In all countries, however, granite has been one of the most popular of building stones. The red granite of Syene was fashioned by the ancient Egyptians into obelisks, sarcophagi and colossal statues, and employed by them in building their temples, pyramids and palaces. Scotch granites are the coarse red from Peterhead, and the gray from Aberdeen. They are used in the United States for monumental work. Both gray and red granite are quarried in Canada, stone of one or both colors occurring in British Columbia, near Victoria; in Quebec, around the lakes at the heads of the St. Francis and Megantic rivers; in Ontario, near Kingston; in New Brunswick, near St. George; and in Nova Scotia, near Shelburne.



GRANITE BLOCKS FOR THE FOUNDATIONS OF THE VICTORIA MEMORIAL, CALCUTTA, FITTED INTO THEIR RESPECTIVE POSITIONS AND NUMBERED AT THE QUARRY SAWMILL BEFORE SHIPPING

Several pink granites are quarried on islands along the coast, especially near Rockland. One quarry in this region supplied sixteen columns, each 26 stone feet long and 6 feet in diameter, for the Cathedral of St. John the Divine in New York City. These were to have been 54 feet long, but this proved to be too great a length to stand the strains of the lathe in which they were to be turned, and the columns had to be made in two sections.

Granites from Westerly, R. I., Stony Creek, Conn., Port Deposit, Md., and Mt. Airy, N. C., are well known, as are also the pink and red varieties from Wisconsin, Minnesota and Missouri.

Granite is so tough that it must be blasted to detach it from the mass. Sometimes it is loosened in enormous quantities, by elaborately arranged blasting, so that tens of thousands of tons are at once made available for division into marketable blocks. It is sawed, not by a toothed saw, but by an untoothed steel bar, that cuts or abrades the rock by friction on minute steel filings; the groove, once begun, is filled with water and with hard steel particles, which furnish the cutting surfaces as the bar is moved backward and forward in the gash by machinery. The dressing of granite is now chiefly done by chipping with chisels worked by pneumatic power.

A MACHINE THAT WALKS TO ITS WORK

A HUGE STEEL STRUCTURE WHICH WEIGHS 200 TONS, AND MOVES STEP BY STEP AT 40 FEET AN HOUR

This platform, carrying a massive electric crane, has two frameworks, one inside the other, each with four legs. It stands on its outer legs, as shown in the picture. When it is to be moved, the inner stage slides forward or sideways by electricity, and the legs are lowered to the position of the dotted lines. The outer stage then slides forward, the legs rising and falling, and carrying the stage one step onward.

GREAT CHANGES IN PRINTING PRESSES 200 YEARS HAVE SEEN

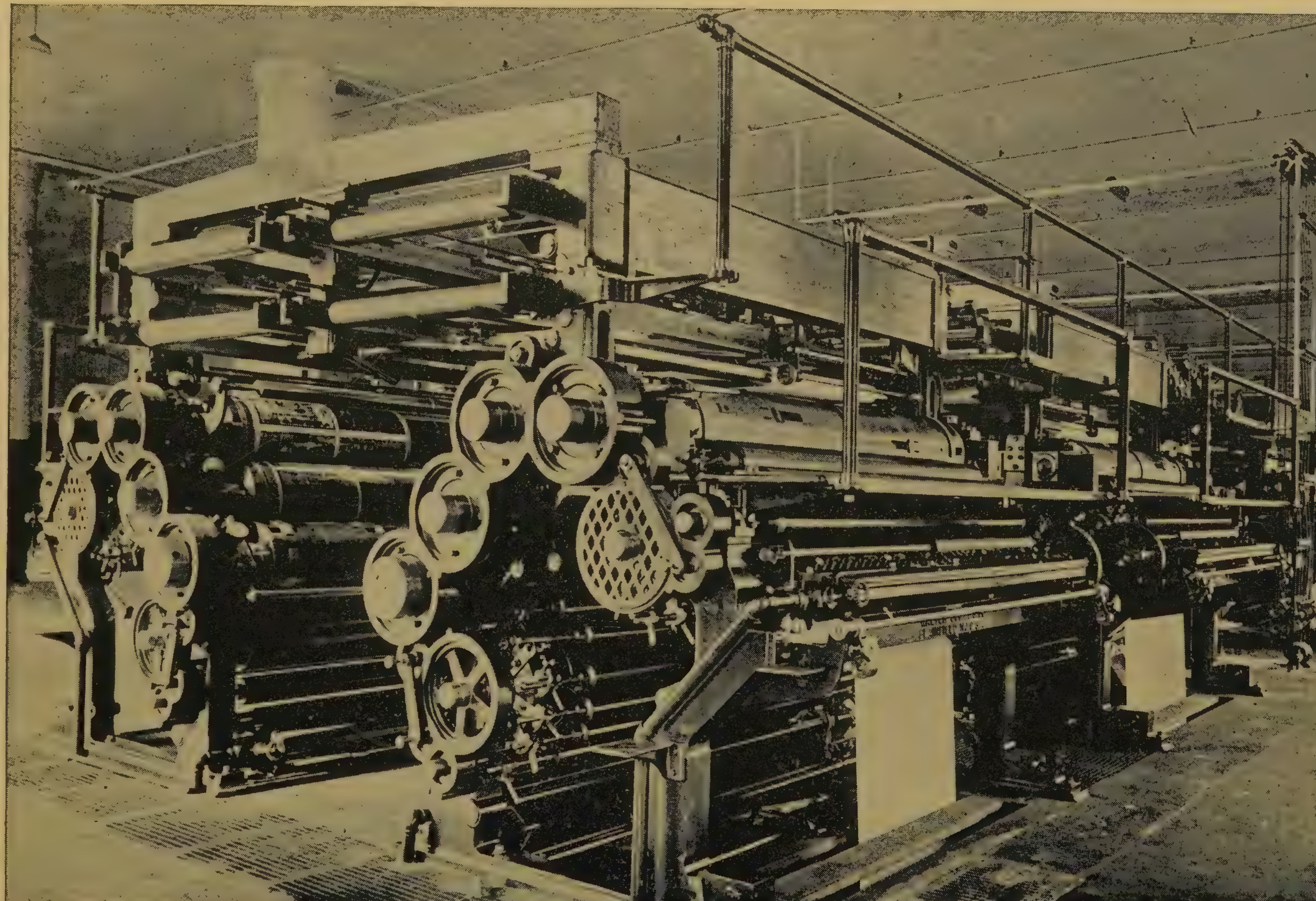
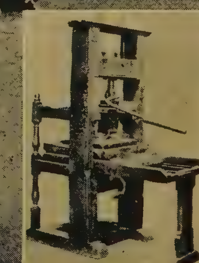


Photo from Ewing Galloway, N. Y.

A battery 200 feet long, the largest ever installed, of Scott Multiple-Unit presses in the plant of the *Detroit News* with a capacity of 432,000 16-page papers printed, folded, cut and counted per hour. The paper is fed to the presses from the basement.



© Ewing Galloway, N. Y.

Benjamin Franklin's printing press, 1725

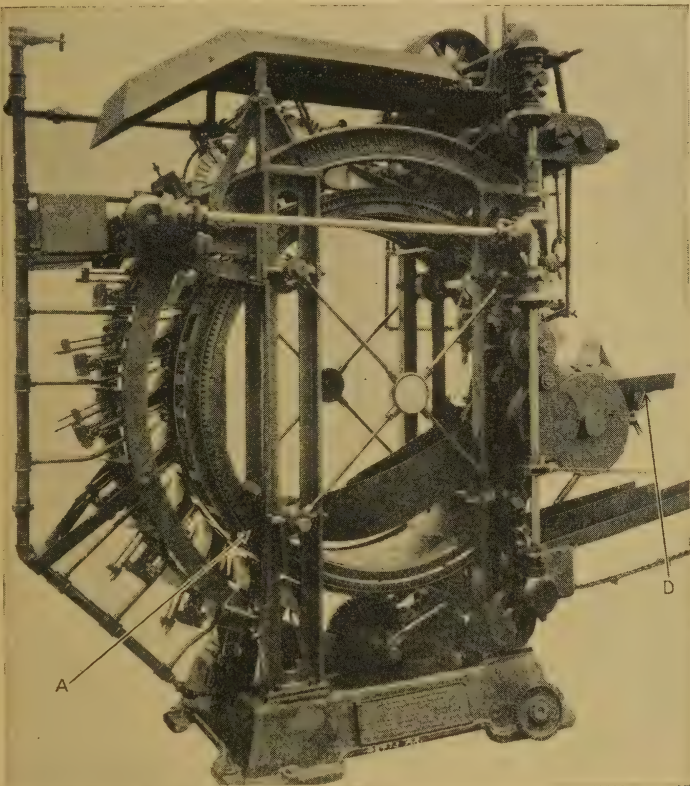
HOW THREE-COLOR PLATES ARE PRINTED

MRS. COOLIDGE ROSES IN A TIFFANY VASE

The subject is photographed three times, through color filters. First through a violet filter to subtract all red and blue, isolating the values of yellow throughout. Secondly through a green filter, subtracting the yellow and blue to leave the red tones. Thirdly through an orange filter, eliminating the red and yellow and yielding the blue values. The resultant halftone plates, made in the usual manner on copper from the separate negatives, are then printed, superimposed, in exact register with effect shown.

These retorts are usually supplied with steam from a steam boiler and are equipped with steam gauges and other controlling devices that automatically keep the pressure, and hence the temperature, at the required point with great accuracy. In most advanced practice the steam is automatically cut off at the proper time and air and water introduced to cool the cans. It is important that the cans be cooled as soon as possible after processing as continued heating is injurious to the product. Cooling is accomplished either by cooling the pressure cooker or by taking the cans out and immersing or spraying them with water. After cooling, the cans are cleaned bright and sometimes lacquered to prevent rusting. The labels are then put on by automatic machinery and the goods are ready for boxing and shipping.

One of the most interesting canning operations is found in the salmon canneries of the Pacific Coast. These splendid food-fish abound from the Columbia River north into Alaska. The method used in catching them and the value and extent of this great industry are described elsewhere. Four of the several varieties of salmon are much used for canning, namely, the Chinook or king; the blue-back or sock-eye; the silver-sides; and the hump-back. The color of the flesh of the several varieties varies from pale pink to a rich reddish color and, while preference is usually for the latter, the lighter colored meats are often really superior. In the early days practically all of the labor of canning salmon was performed by hand, and as much of the preliminary work was dirty and disagreeable, the only men who could be persuaded to do it were Indians and Chinamen. The labor problem was further complicated by the short season character of the work, salmon canneries operating only for a few weeks while the salmon are running up the streams to spawn.



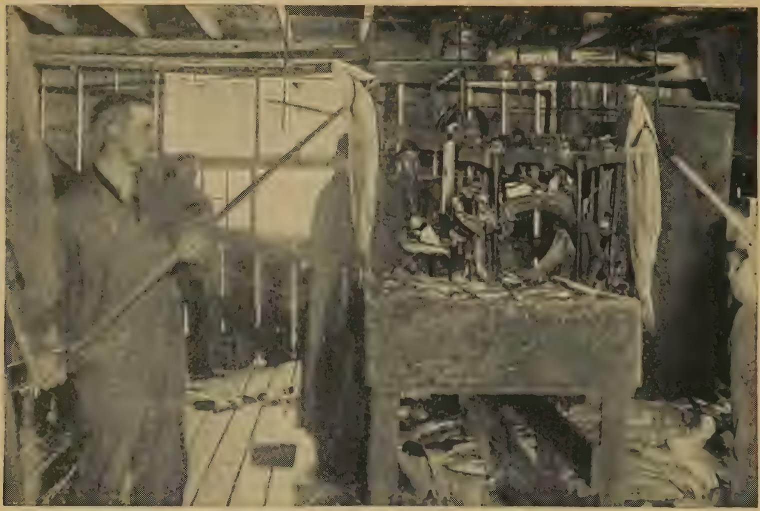
Courtesy Smith Cannery Machines Co.

IRON CHINK FOR CLEANING SALMON

The operation of the machine is entirely automatic; it removes the head, tail, fins, entrails and blood of any salmon weighing from two to twenty pounds at the rate of sixty per minute without adjustment for the different sizes. It does the work of sixty expert cannery laborers. *D* is the feeding table. The header attachment first removes the head from the fish, which then enters the chink tail-end first, belly up, and in the course of its journey around the large wheel *A* a set of revolving knives cut off the tail, then another set divest it of its back fins and still another of its vent, belly and gill fins; a revolving knife at the top of the circuit opens the belly, and revolving gutter wheels directly following sweep out the entrails; the sliming and washing is next done by the sliming mechanism directly opposite the point of entry of the fish. Water under pressure is forced into the fish while the slimers are doing their work, which absolutely removes all refuse.

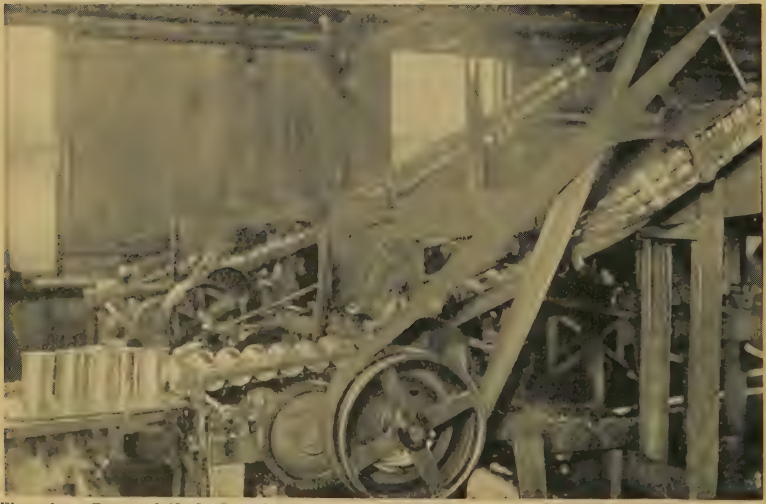
These conditions led to the invention of the "iron chink", so called from the fact that "chink" was the local name for Chinaman. The iron chink is easily the most interesting machine in the entire field of the canning industry and certainly one of the most ingenious ever invented by man. While it may look complicated, it is really very simple in operation and unlikely to get out of order.

HOW THEY CAN THE SILVER HORDE IN ALASKA



The "Iron Chink", into which the salmon are fed, tail first, at the rate of one a second. They come out of the machine with fins, tail and entrails removed, with the inside well washed out and the outside scrubbed clean.

Cutting up machine, in which the salmon are carried automatically against the revolving knives seen at the top of the machine and thereby cut into pieces.



Automatic filling machine which packs the salmon into the can.

Photo from *Report of Alaska Investigations*, by Dr. E. Lester Jones, U. S. Bureau of Fisheries

BUILDING AN AUTOMOBILE

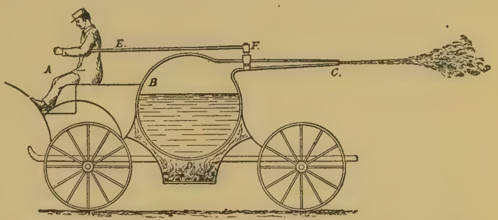
The Wonders of the Machine That Enables a Man to Live Next Door to Everywhere

THE AGE OF THE HORSELESS CARRIAGE

ADVENTUROUS spirits in all times have had a keen desire to fly through the air like the birds, and to traverse the land and skim the sea at great speed and with perfect freedom of motion. Mythology and the early literature of our race abound in stories and speculations pertaining to such accomplishments, but until the invention of the steam engine the best that man could do was to harness the winds to move his ships and utilize animals for rapid transport on land. The invention of the steam engine and of the gas engine has altered all this and has made it possible for us to navigate air and sea and to annihilate distance on land, in a manner that would almost justify the ancient mythological superstitions and the tales of the Arabian Nights.

The period of modern speculation on this problem appears to have begun about the thirteenth century. Roger Bacon, an English Franciscan monk living in that time of ignorance of mechanical matters, wrote in one of his learned treatises: "We will be able to construct machines which will propel large ships with greater speed than a whole garrison of rowers, and which will need only one pilot to direct them; we will be able to propel carriages with incredible speed without the assistance of any animal; and we will be able to make machines which by means of wings will enable us to fly into the air like birds." This most remarkable prophecy at a time when none of the means of its fulfillment were in sight has all come to pass, and it would be interesting to know the grounds on which this philosopher based his predictions.

Bacon made no practical suggestions as to how he expected these things to come about, but in 1680 Sir Isaac Newton suggested the road locomotive shown in the accompanying illustration. It consists of a spherical steam generator *B* under which is a fire-grate *D*, the whole mounted on a carriage. A long nozzle *C* projects from the generator in a rearward direction.

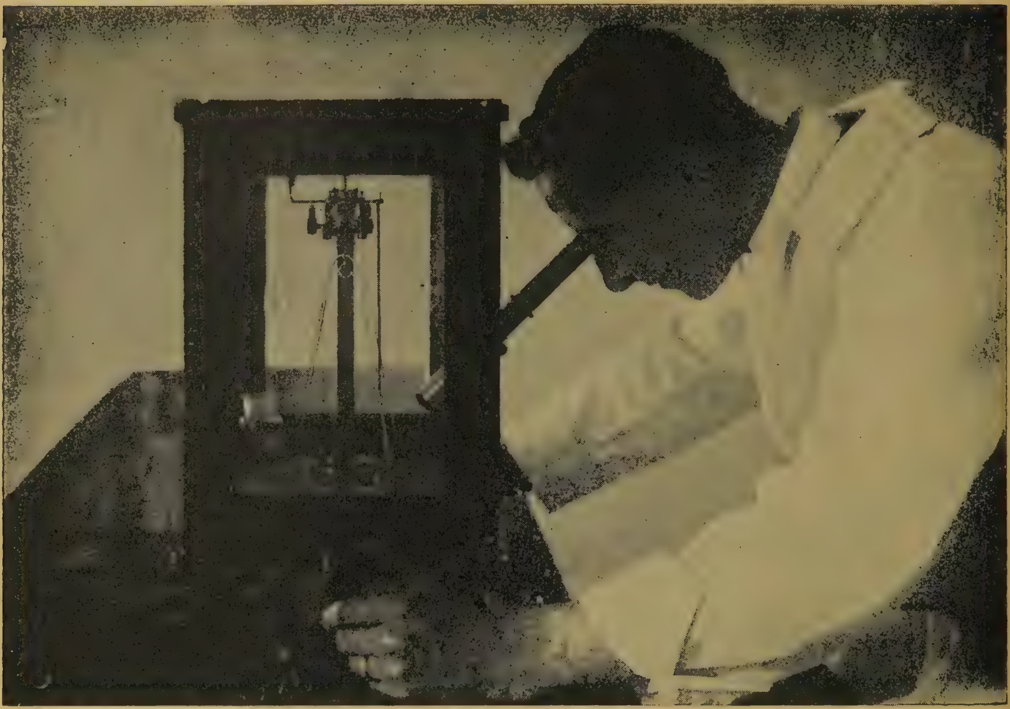


SIR ISAAC NEWTON'S STEAM CARRIAGE (1680)

The steam issuing from this nozzle at great velocity will react upon the air, thus driving the vehicle forward. The valve *F*, which admits steam to the nozzle, is under control of the driver through the lever *E*. We have no record showing that Newton ever built such a machine, though the idea, while crude, is feasible.

The invention of the steam engine near the end of the eighteenth century naturally revived speculations as to the possibilities of flying and of power-driven vehicles, and many interesting and curious suggestions were made bearing upon these problems. An English linen draper named Francis Moore invented a self-propelled vehicle in 1769 and was so sure of its success that he and many of his friends sold their horses. Watt himself was not very enthusiastic over the use of the steam engine for vehicles and appears to have discouraged it.

WEIGHING A GRAIN IN A MILLION PARTS



THE MARVELOUS SCALES WHICH WILL WEIGH THE MILLIONTH OF A GRAM OF RADIUM

A GUILLOTINE WHICH WILL CUT A 25,000TH PART OF AN INCH

By vaporizing matter at a high temperature and analyzing its light, the most minute traces of an element may be detected. A millionth part of a grain of calcium can be traced, and even one 180-millionth part of a grain of sodium. The sensitive balance is a precision instrument now for the chemist and the microtome, slicing extraordinarily thin sections of plant and animal tissues, is of inestimable value to the biologist and pathologist.

A PICTURE OF PORTSMOUTH HARBOR BY A MASTER OF ATMOSPHERIC PAINTING

This water-color painting by J. M. W. Turner shows the way in which cloud and mist affect the clearness of a landscape.

FACING PAGE 1792

THE ROMANCE OF RUBBER

The Romance of a Boring Beetle, a Tree's Defense, and of Wealth and Comfort for all Mankind

HOW THE WORLD'S SUPPLY HAS INCREASED

IN rubber, nature has devised one of her most interesting forms of defense for the protection of certain varieties of vegetable life. The existence and purpose of rubber are a mystery to the forester, but the entomologist, studying the life of insects, holds the key to the secret. He knows why the precious latex is there though the forester does not. On the face of it the existence of the substance is a little puzzling. It is no part of the sap; it has absolutely no relation — normally, at any rate — to the nourishment or growth of the tree. Like the frightful carnivorous teeth in the manlike ape, which is an herbivorous animal, this latex is, in the main, a defense.

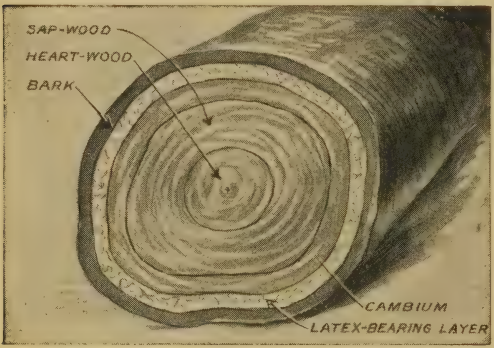
It sallies forth from a breach which an enemy has made in the bark of the tree. It may poison or entrap the intruder. It certainly closes the breach, heals the wound, and renders the tree able to pursue the healthy course of its life. The latex, or milk, of the plant or tree coagulates on reaching the air, as blood coagulates to prevent our bleeding to death from the wound by which it emerges. It possesses its pliability in order that with the swaying and tossing of the tree in storm or wind the closing of the wound may not be broken open, as would happen were the covering brittle like sealing-wax. The latex, flowing from a puncture, prevents the ingress of the original intruder; it also defies the deadly fungus that attacks any morbid area in a tree. Rubber gloves keep the operating surgeon's hands immune from the deadliest bacteria; rubber plasters enable a wounded tree to combat the beetle and fungus spores.

For it is the beetle, the wood-boring beetle with its powerful saw, that the rubber tree is specially armed to fight. To that small insect, not to any creative merit of our own, do we owe all the rubber that is in the world. The wood-borers puncture the bark and lay their eggs in the wood of trees. The eggs develop into larvæ, which devour the living substance of their host. Trees that have been drained of rubber are found enfeebled and dying, riddled by the wood-boring beetles. In such a case the tree, bereft of its only weapon, is as an unarmed man confronting a ravening carnivorous enemy; or, rather, like a man lying outdoors at night, without the protection of a mosquito-net, in the haunts of the deadly tse-tse fly that carries the germ of sleeping sickness.

The rubber tree is armed, in the words of the old Minute-men, for "defense, not defiance," and the milky fluid flowing through its bark is the armament upon which its safety depends. Because there exist certain beetles having strong thrusting implements with which they are able to bore into trees to let their larvæ live and feed upon the body of the tree — as, within more restricted limits, the larva of the ichneumon fly lives within and consumes the body of the hapless aphis or greenfly — because of this we have tires for automobiles and adequate insulation for cables that cross the ocean and carry a message round the world in almost as short time as that in which it is written.

It is a fascinating story that the entomologist-botanist thus reveals; but, of course, there is nothing in nature quite without a parallel.

So if this rubber, a fluid flowing within the interior of a tree, be a wonderful substance it is not more so than the silk which spider and caterpillar produce from within their small bodies. Every young microscopist, when he first begins his studies, makes an effort to dissect the spider, with a sort of idea that he will discover the silk, of which it spins its web, neatly wound up within the little creature's anatomy. But he is disappointed; and then he thinks that he must have chosen the wrong species, or perhaps the wrong sex, for he discovers nothing but an accumulation of dark, viscid fluid, where he had expected to see a silk factory in miniature. But that viscid fluid is the substance of which the spider spins its web.



CROSS-SECTION THROUGH A RUBBER TREE

The silk a lady wears is, when within the body of the silkworm, a similar fluid, but after it is drawn out and coagulated it is the strongest dress fabric known to man. We have mastered the secret of the silkworm, and can now produce artificial silk — from paper; we have mastered the secret of the composition of rubber, too. We have broken it up into its constituent elements, and can build these artificially as we can build up artificial indigo. But whereas the latter killed India's trade in the natural article, natural rubber remains unaffected by the discoveries in the laboratory, for the sufficient reason that it costs more to make rubber than to grow it. Cheap synthetic rubber may eventually come, but the hour has not yet arrived, and we still rely upon that first and most economical of supplies — nature's own. But, as we shall see, we have enormously helped her to increase that supply.

There, then, is the strange story of the genesis of rubber. It has its parallels in the productions of the larvæ of certain insects, though the aim and application are different. It has a closer analogy in the defenses of many other plants in which a wound is followed by the discharge of a virulent poison. Opium, that has blighted so many human lives, is a development corresponding to the latex of the rubber-tree.

That fluid resides, however, not in the stalk of the plant, but in the great seed-head. When the latter is wounded, there issues from the scratch or puncture a milky fluid, deadly to an insect, and at the same time serving, by rapidly drying, to close the wound. And so, for ages past, thousands of human beings have been making a living by artificially wounding poppy-heads and stimulating a flow of the juice, to pick it off when it has hardened, work it into cakes, and convey it to the factory for conversion in commerce into the beneficial opium of medicine or the destructive agent of the drug fiend.

Nature never bestows an unnecessary defense. And had there not been this natural defense against insectile attack, we should today lack many of the most important aids to civilization. The first use of rubber was one of those primitive fundamentals of observation and ingenuity such as in early times gave man the fallen log for a raft on which to take an experimental journey afloat. The inaugural aquatic adventure was probably a sporting trip; the first use of rubber by man was undoubtedly for pastime. Columbus, upon his second journey to Haiti, found the natives playing with balls made of the substance, and he noticed with surprise how the playthings bounced. But he little dreamed that the natives' toy possessed potentialities of wealth greater than any of the concrete riches he saw and coveted. Mines become exhausted and cannot be renewed, but rubber goes on growing and re-creating itself from seed.

The Haitians were wiped out of existence in the course of a generation by the abominable cruelties of the Spaniards, and their places taken by negro slaves,

HOW BUTTONS ARE MADE

The Mussel Fisheries and Pearl Button Industry of the Mississippi River

THE STORY OF VEGETABLE IVORY AND MUSSEL

TO the average person the button is a rather trivial object. Indeed the word has always been used in comparison as of something of little value. Yet buttons are among the most indispensable of small conveniences, and the use of them as such marks a high stage of civilization. The savage fastens his blanket or tunic, his leggings and moccasins, with strings. The flowing garments of the Greeks and Romans were also confined by strings and they wore an occasional gem to fasten the toga at the neck. Indeed, the button first appears not so much for use as for ornament.

A number of very ancient buttons were discovered by Professor Flinders Petrie in a tomb at Kopt, Upper Egypt, some years ago. The oldest of the lot, probably the oldest in the world, is of amethyst and about one inch in diameter. It is Egyptian in design, although clearly made by foreigners and represents a sacred hawk, which was the emblem of a royal soul, standing facing another hawk with the ankh, emblem of life, between them. A captive lies below the hawks. This button is credibly connected with a period 2500 B.C. Another interesting button found by the same explorer was taken from a tomb at Negadah, Egypt, with a quantity of beads of the Twelfth dynasty, which connects it with a period 2000 B.C. The button, in which there is no trace of Egyptian ideas, is of lapis lazuli; the design cut thereon appears to be an ape walking, with some inexplicable lines above the back of the ape. Below is the "thunderbolt", by far the earliest example of that famous sign known to history. Both of these buttons have piercings through the shank for the fastenings. Buttons sewed through small holes close to their edges are of a period somewhere about 2000 B.C., for in those known as Greek "island stones", made of blackened limestone, this very arrangement prevailed.

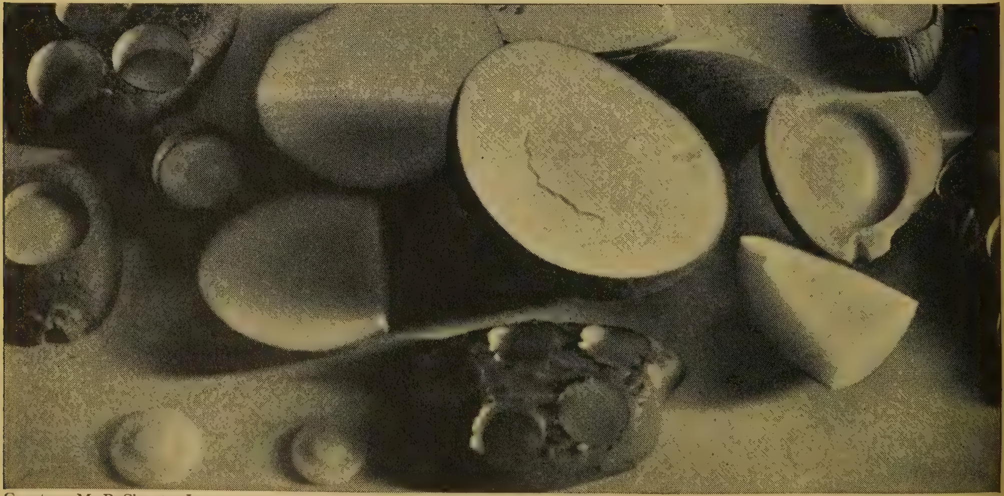
Buttons were first used in southern Europe about the thirteenth century, and were applied to dress for purposes of ornamentation only. In a manuscript poem written not later than 1300, we find the first mention of them where the hero is described as wearing buttons from his elbow to his hand. The employment of buttons increased to such an extent in the fourteenth century that their lavish use on fashionable attire was the occasion of unfavorable comment in the literature of that period. During the following century they were somewhat less in vogue. Lace and points appear to have superseded them, but they recovered their ascendency in the sixteenth century and were worn in great numbers on the dress of both sexes. They were of infinite variety as regards size, shape and material, which included gold, silver, brass and other metals, wood, horn, bone, glass, silk, cloth and velvet. In the time of Charles I, handkerchief buttons were much in style. Tastes were extravagant and we find frequent mention of buttons made of diamonds and other precious stones. Louis XIV is said to have had a positive mania for buttons, spending in a single year, that of 1685, over $600,000 for them. He bought two diamond buttons for $14,000, 75 for $120,000, and the set for a single vest cost over $100,000.

Courtesy M. B. Shantz, Inc.

IVORY NUTS FROM WHICH THE OUTER HUSK HAS BEEN REMOVED

leaves for 5 or 6 years, forms the trunk, at that age not over 3 or 4 feet high, crowned by a canopy of leaves resembling large green feathers. At this time fragrant blossoms appear at the bases of the lowest leaves to be fructified by the pollen borne to them by the winds or carried by the myriad insects from the nearby male tree. Each fruit is composed of a dozen or more separable fruits, one of which, broken open, is shown at the right side of the picture. In each section of the large fruit, there are four to six seeds the size of an egg. These are embedded in pulp and many coverings and are first in the form of sacks of sweet, refreshing liquid that changes into a soft, delicious pulp, and finally becomes the hard nut of commerce.

The nuts mature very slowly, requiring fully a year from blossom to full ripeness. A collection of 60 to 90 nuts in groups of 5 or 6 are incased in one huge, knobby husk resembling a chestnut burr but much larger. (See frontispiece of this chapter.) This head opens at the bottom when the nuts are ripe and lets them fall to the ground. They are covered with a thin, oily substance which attracts the wild hog, guanta, guatusa, squirrel and other rodents that leave the nuts clean for the gatherer.



Courtesy M B. Shantz, Inc.

SECTIONS OF IVORY NUTS

Care in sawing must be taken to avoid the cracks that occur in drying.

ONLY MONUMENT IN THE WORLD TO AN INSECT

MONUMENT TO THE MEXICAN COTTON-BOLL WEEVIL, ENTERPRISE, COFFEE COUNTY, ALABAMA

Before the invasion of the boll weevil in 1915 the average cotton crop of this county was about 35,000 bales. The yield was cut the first year to 60% of normal and, in spite of the use of every conceivable means to exterminate the pest, to 10,000 bales the second year and to 3000 the third. Realizing that something had to be done and that quickly, diversification of crops was tried with the happiest results. Peanuts, corn, hay, sweet potatoes and sugar cane were grown, the yield of the first-named breaking the world's record for area involved and cash return — over five million dollars — and hogs and cattle were raised and shipped in trainload lots. Enterprise, one of the county seats, is surrounded by small farms of from 50 to 250 acres each owned by 1500 thrifty farmers with pretty homes. The inscription on the base of the monument reads:

"In profound appreciation of the boll weevil and what it has done as herald of prosperity this monument is erected by the citizens of Enterprise, Alabama, December 11, 1919."

THE COTTON OF THE WORLD

The Story of the Flower of the Field That Gives Work to Millions and Clothes to All

THE SOURCE OF PROSPERITY OF THE SOUTH

AN interesting argument might be started as to which vegetable growth is most important to man. Is it wheat for the feeding of the man of the earth's temperate regions? Is it rice, for the sustenance of the people of the warmer climates? Is it the potato, which enables men to grow more food per acre than in any other way? Is it cotton, which clothes the vast majority of mankind, in part or wholly, and also indirectly provides valuable food? Is it the vine? Will it be the rubber tree?

While most of the people who read and write books would decide for wheat as the most important vegetable product, a case might be suggested for cotton, because admittedly its importance is enhanced by the fact that the earth does not provide any substitute for it. It is cotton or nothing for clothing the poor people of hot lands.

Whether cotton is or is not the most important vegetable product, it certainly is the chief vegetable fiber. Nothing similar is grown to such a stupendous extent, or occasions the expenditure of such varied manipulative skill. In its manufactured form it is known to every man between the Arctic Circle and the remotest equatorial swamps. Its growth has caused the greatest transplantation of a backward race from continent to continent whereof the world holds record. Gradually, too, its predominance is extending, for decade by decade it clothes an increasing percentage of mankind while its competitors in the world's clothing trade are falling farther behind in the race, even when they are not slackening their pace. At present, cotton has no rival; nor will it have until a form of patent clothing is invented equally comfortable and attractive and cheaper. Mankind wears three times as much cotton as wool.

There is a striking universality in the use of cotton throughout the world, if not through time. Though wool was the ware in ancient Europe, and linen in ancient Egypt, the use of cotton was known, as an echo from the East. Herodotus was aware of the "fleeces from the trees," and admired their effect in fabric form. For nearly three thousand years, India has had cotton manufactures unsurpassed in certain qualities. The word "calico" itself is from the Indian town of Calicut. When the Spaniards appeared in America they found the natives of the southern continent wearing cotton garments so well dyed that they sent them home as curiosities and as proofs of the stage of civilization attained. The countries that now supply the world with its calico prints were backward in beginning the manufacture of cotton cloth.

The modern change has been brought about, of course, by the impetus of invention and an early start with machinery. Europe first received the industry from the Moors, and it is said to have come to England from the Turks by way of Flanders, but there was no considerable progress until Richard Arkwright invented his "water-frame" for spinning, which enabled an all-cotton fabric to be produced by machinery, cotton being used for both warp and weft. Then England began to make the world's cotton goods, and America to grow the cotton.

amount to about half the original weight, are crushed, then cooked, then placed under a hydraulic press, so that the oil is squeezed out. The solids remaining are next either ground into meal for a cattle food, or pressed into cotton-seed cake for the same purpose. The crude oil amounts to about forty gallons from a ton of seed. The settlings of the oil are used in soap-making, and the clearer oil is refined by heating, and by treatment with potash, which causes its impurities to be deposited. This refined oil is known in commerce as "summer yellow," or, in its purest forms, as "butter-oil," and it is used in the manufacture of oleomargarine and butterine. Under cold pressure it is changed into salad-oil, and becomes an alternative to olive-oil, or is sold as such.

The enormous production of cotton-seed oil in the United States

When bleached it finds a market as a substitute for lard, or is known as "cottolene." Under cold pressure it becomes "winter white oil," and is used in the manufacture of medicines, as well as for miners' lamp-oil and for soap-making. The United States alone has produced as high as 230 million gallons of cotton-seed oil in one year. In 1919 the production was 161½ million gallons valued at 210 million dollars. The most familiar form in which cotton-seed oil meets the eye of the householder is in the anchovy and sardine tin, the fisheries of western France being almost entirely supplied with cotton-seed oil from the United States and Egypt.

The price that raw cotton will command depends on the ripeness, length, and fineness of the fibers. Unripe fiber has to be removed ultimately. The farmer, when paying the ginner for his work, may wisely pay for the running of the machinery at a lower speed, so as to preserve the quality of his product and secure the exclusion of waste matter. After ginning, the cotton is forced into as small a bulk as possible under a baling-press, because freight is payable on bulk as well as weight. An average American bale weighs 500 pounds, an Indian bale 400 pounds, and an Egyptian bale 700 pounds.

The concentration of the growth of cotton in the American cotton-fields

The question of the concentration of the growth of cotton in one place — the southern part of the United States — has engaged the attention of manufacturers of cotton goods in all countries since the calamitous ruin of their business by the stoppage of supplies of raw cotton during the Civil War; but though there has been a considerable development in India, and a notable increase in production of good qualities in Egypt, the United States still supplies the world with 75 per cent of its cotton crop. Among the cotton-producing countries are Brazil, the West Indies, Peru, China, Korea, Japan, Turkestan, West Africa, and the East Indies.

THE COTTON FIBER MAGNIFIED

One pound of this fiber can be spun into a thread 100 miles long. An average picker will gather a hundred and fifty pounds a day, a fast picker as much as three hundred pounds.

The first attempt to raise cotton in America was made in 1621 in Virginia. At no period in Colonial times was it a really important industry, Whitney's invention coming after the Revolution. Its wonderful growth during the past century and a quarter has contributed vastly to the wealth of America. A large share of New England's prosperity has come from its cotton mills, and, during the last thirty years or more, the establishment of mills in the home of cotton itself has increased the opportunities of that section by adding the

SKILFUL CUTTING OF A RUBBER TREE

THE METHOD OF REMOVING THE BARK TO PROMOTE THE DEFENSIVE FLOW OF THE MILK

rapidly coming into use, its flexibility being particularly adapted to some of the operations involved. Near the mill, but at a safe distance, is the "burner" which disposes of the refuse and sawdust not used in firing the boilers. The burner consists of a boiler plate shell 25 to 40 feet in diameter and sometimes nearly 100 feet in height. It is lined inside with brick and fitted with draft doors at the bottom. The dome-shaped top is covered with a metal screen to prevent sparks from escaping. Automatic chain-scrapers drag the waste into the burner and the roaring fire rapidly consumes it. The former method of burning it in open fires was found too dangerous. A large mill with its surrounding piles of lumber is always a bad fire risk, and once the flames get started it is very difficult to check them. Special fire fighting apparatus has been developed for this purpose.

Attached to most of the large sawmills are planing mills and dry kilns for removing the moisture in the lumber before it is finished in the planing machines. Dried in this way in heated rooms, lumber is not so strong as when seasoned by piling out of doors to dry in the open air. But the latter is a long process, while the dry kiln removes the moisture in a few hours. Natural seasoning also requires large yard room if big quantities are to be handled.

Large mills, like these, are permanent establishments representing heavy investments of capital. They must be built, therefore, in some location where the logs can be easily brought to them by rail or water. It is not uncommon, however, to build small sawmills in the forest itself, cut all the logs within easy reach and then remove the mill, or at least the machinery in it, to a new location. Small mills for sawing shingles from the giant cedar trees of the West Coast are often thus moved.

Photo Nowell

A BIG STICK HOLDING FIFTY-THREE VARIETIES AT THE UNIVERSITY OF WASHINGTON, SEATTLE

Often, when the mill is situated in an isolated spot, a town will grow up around it, wholly supported by the industry, and sometimes owned by the proprietors. A few years ago on the Pacific Coast in any large mill town on tide-water there could be found a very cosmopolitan gathering. Sailing vessels of many nations, carrying lumber to all quarters of the globe, left behind them men of different races.

How comes it, then, that physically charcoal and diamond are so unlike? It is simply an example of molecular difference, such as also gives us varying forms of sulphur and phosphorus. The nature of any substance depends not only on the element or elements composing it, but also on the molecular arrangement of the elements. Diamond is different from charcoal simply because its molecules of carbon are differently built up.

We find this difference in physical properties with identity in chemical composition, not only in pure carbon, but in many compounds of carbon. Thus, benzonitrile and phenylisocyanide molecules are each composed of seven atoms of carbon, five of hydrogen and one of nitrogen. Yet the first is non-poisonous, with the pleasant odor of bitter almonds, while the second is poisonous, and has a very offensive smell. It is plain that such a difference must depend on different arrangements of the atoms in the molecule.

QUARTZ CRYSTALS, THE PUREST FORM OF SILICA

Led by such suggestive facts, chemists began to try to discover the position of the atoms in the molecules of the various substances, and to represent the supposed position by a similar disposition of their symbols on paper.

In this way the new and very important branch of chemistry known as stereochemistry, which deals with the special relations of the atoms in the molecule, was born. We can now in many cases picture to ourselves the position of the various atoms composing a compound molecule, which is surely one of the greatest feats of scientific imagination. But this is somewhat of a digression.

Let us return to the diamond, and give it a little separate consideration. As we have said, it consists of carbon, and differs from pure charcoal or pure soot merely in the arrangement of its atoms of carbon in the molecules. Its radiancy, its hardness, its durability and its rarity have made it the king of gems, and diamond-mining and diamond-cutting are big and important industries.

In spite of the commercial and social value of the diamond, the facts of its geological genesis are unknown. All we do know is that ordinary carbon can be changed into diamond by great heat and pressure. Minute diamonds can be produced artificially in the following manner: pure iron is mixed with carbon and packed in a carbon crucible, and the crucible is put in an electric furnace and subjected to a temperature of 4000° C. At this temperature the iron melts and absorbs carbon, combining with some and dissolving more. After a few minutes' heating, the crucible with its contents is plunged in cold water. The outer layer of iron solidifies, and the expansion of the iron in the center as it cools (for iron expands as it cools) is checked by the solid outer layer, and in this way tremendous pressure is produced. Under this pressure the dissolved carbon separates out in a hard, transparent, dense mass, where — after several other chemical operations — are found graphite, minute black diamonds and also minute colorless diamonds.

It is probable, therefore, that diamonds were formed at a great heat, and under great pressure in masses of molten iron

A MANUFACTURE BEST ESTABLISHED NEAR THE SOURCE OF ITS RAW MATERIAL

TWENTIETH CENTURY PAPER MILLS BUILT BESIDE GRAND FALLS, NEWFOUNDLAND, WITH FOREST, WATERWAY AND WATER-POWER NEAR BY

Newer transportation methods facilitated the distribution of the mail, and, as a result, correspondence rapidly increased and newspapers multiplied. Supplied with a machine and his market, the manufacturer was compelled to cast round for an entirely new source of supply of raw material. He had to find a vegetable substance which he could resolve into its constituent fibers to replace the ready-made fiber of the rags of linen and cotton, etc., which he had been in the habit of using.

The wasp that has held the paper-maker's secret for ages and ages

Probably he did not go to the wasp for guidance, but it was there that the secret lay. The wasp has been from the beginning of insect history masticating woody and other vegetable fibers and producing paper from them. And that is what the modern paper-making plant does. It is a colossal mechanical wasp, which masticates wood and grasses and the straws of cereals, and binds their fiber into miles upon miles of paper.

Esparto, or alfa grass, was the first vegetable substance with which commercial success was gained, and an extensive trade sprang up in paper made from this substance, and southern Spain and parts of northern Africa were exploited for the grass which had suddenly become an asset. But soon demand outgrew supply, as in the case of rags. Where the rag-gatherer had formerly kept the paper market going, now, with the spread of education, rags, plus enormous supplies of esparto, failed to satisfy the needs of the paper mills. Rag returns about half its weight in paper; esparto yields about one-sixth of its weight. So other supplies had to be found.

The search all the world over for materials that will make paper

The world has been ransacked for suitable vegetable growths. In scores of mill offices one may see little bundles of dried vegetable fiber, numbered and described. The traveler in the distant wilds sends these home, with a memorandum saying: "The natives call this substance so-and-so; they use it for such and such a purpose." The manufacturer consults the botanist and the chemist for an answer to the question: Will it make string or rope, or sacking or canvas? Best of all, will it make paper? Experiments are constantly in progress in chemical laboratories throughout America and Europe with a view to discovering new supplies from the growths sent from afar. Edison sent men on a world-wide tour to gather materials out of which to fashion filaments for his incandescent lamp, but the paper-maker has men constantly out and about the world.

He gathers flax from Russia, Turkey, Italy, Egypt, France, Belgium, and Ireland. He takes the hemp of Russia, Italy, Turkey and Hungary and New Zealand, and the best that India can grow. He uses cotton from our Southern States, Egypt, and India; jute from India; straw from Holland, Germany, and our own country; esparto from Spain, Algeria, Tunis — and Tripoli. These are the principal sources of fixed supply. But they do not suffice. The chemist has to be summoned to analyze unconsidered potentialities. And in the end he reports favorably on the straw of flax, on banana skins, bamboo, the dried stalk of the sugar-cane, on peat, on the waste hulls of cotton seed. The paper-maker goes back to nature for inspiration. In her laboratory there is no such thing as waste, and he finds in waste products raw material for his trade, yielding greater treasure even than is hidden in all the tons of refuse containing radium, which were scattered on the dump-heaps of every great city in days when radium was unknown.

The basis of a library which is formed in a forest

But, so far, we have said nothing of the pulp of wood. That, today is the great stand-by of the paper-maker. The giant of the forest, subdued by machinery, becomes a pulpy mass which the great mechanical wasp bleaches and beats and hardens and smooths and glazes until it issues from the machine in the form of paper, indistinguishable by any but an expert from paper that is made from cotton and linen rags.

THE PORTLAND VASE

An insane visitor to the British Museum in 1845 broke with a stone this fine example of cameo glass into a hundred pieces, but, as the picture shows, it has been repaired with skill.

THE MARVELS OF GLASS-MAKING

Windows Through Which We May
Gaze on the Inner and Outer Universes

HOW INDUSTRY GIVES EYES TO SCIENCE

ONCE upon a time some Phœnician merchants beached their galley laden with niter at the mouth of the river Belus, in Syria, and prepared to cook their meal on the sands. Finding no stones on which to set their kettle above the fire, they used instead some pieces of niter from the boat. When they had finished, and the fire was out, they started to take up the blocks of niter, and found that these had melted in the fire, and combined with the fine river-sand to form a strange transparent substance. It was thus that the first and most important step in the art of glass-making was discovered by these adventurous merchants from Sidon. For the niter that they used to support their cooking-vessel was an impure form of carbonate of soda, and the fire, fanned perhaps to a great intensity by the sea-wind, melted the soda and sand together and produced a glass-like material. The Phœnicians were a very intelligent race; they experimented with the inferior glass they had discovered, and at last found that by adding a certain quantity of manganese they could produce a marvelous material of crystal clearness that could be made into a variety of objects.

Such, according to tradition, was the accidental origin of one of the most wonderful objects of human manufacture. In the last twenty-five years so many marvels have been discovered that men have had their sense of wonder dulled by continual excitement. We can now create strange rays that can make many substances transparent to our vision, and we are so proud of these new wonders that we lose sight of equally marvelous things of everyday use that surround us. Yet the discovery of glass is just as extraordinary an achievement of human genius as the discovery of X-rays and radium. When men were able to manufacture in a large way a firm, solid material that was transparent to light, the destinies of the human race were altered. Mankind became possessed of faculties undreamt of by the most imaginative of wizards; for glass was an instrument of tremendous power, that enabled man to open the two gates of infinity — the infinity of the outer universe of space, the infinity of the inner universe of life.

Glass is the tool by means of which man controls light. It enables him to flood his dwelling-place with the cheerful and vital radiance of the sun, placing him beyond the chances of the weather, doubling his powers of work, and keeping down the germs of disease that undermine his health. It is glass that renews his faculty of vision when his eyesight grows dim. It is glass that enables him to construct a multitude of finer and more delicate senses, by which he penetrates to the bounds of the universe, dissolving a flaming star on the confines of space into its original elements, and by which he discovers the invisible forms of life in the dust beneath his feet. And the wonderful pictures that print themselves upon the sensitive plate of a camera are obtained by means of lenses of glass.

Without the discovery of the process of glass-making, man could never have grown to his full stature, and there would have been no hope of his ever obtaining a wide knowledge and more complete control over the resources of nature. For glass is the real foundation of modern science.

Lacking glass, the human race could have gone on building up civilization after civilization; it could have developed its sense of beauty, its sense of religious awe, and its skill in various industries, but it could never have established the solid and deeply laid structure of sheer and far-reaching power over the processes of matter which may one day enable it to comprehend in part the Mind of the universe. Science without true religious feeling is power without aim.

The time when glass was worth its weight in solid gold

For some thousands of years glass-making was mainly a fine art of an exquisite kind. Even when the Book of Job was written glass was worth its weight in gold; and the Phœnicians seem to have traded glass beads as jewels among the savages of northern Europe. It used to be thought that the ancient Egyptians, at an early epoch, anticipated the discovery made by the merchants of Sidon, for a drawing of two workmen, apparently engaged in glass-making, has been discovered in a tomb of the eleventh dynasty at Beni Hassan. But the best authorities now agree that the drawing represents some metallurgic process. The Sidonians certainly held for a long time the monopoly in glass-making, and they spread the use of the new material throughout the Mediterranean. But gradually a knowledge of the secret of its manufacture extended to Italy, Spain and Gaul, and the Romans especially became admirable artists in glass.

The beautiful Portland vase, so called from the family which loans it to the British Museum, is a fine example of the Roman's skill. It is about a foot high, of transparent dark blue glass coated with opaque white glass cut away to resemble a cameo. It dates probably from the first century B.C., and was found in a sarcophagus in Rome about the middle of the seventeenth. It had been used as a cinerary urn. When Josiah Wedgwood in 1786 came to copy it in his new style of pottery, he estimated that, even if he could find an artist with the genius to execute such a work, its original cost would be at least $25,000.

The Roman cheapening of glass from table use to window use

As a matter of fact, wealthy Romans used to pay extraordinary prices even for small glass vases of exquisite workmanship. They were esteemed above vessels of wrought gold. Table-glass of fine and elaborate shape was at first the principal glass industry of the Roman Empire, but mosaic work, made by combining bits of colored glass into a pictorial design, was soon developed in a variety of beautiful ways.

But the practical Romans at last found the cheaper process of making window-glass; and just as their empire was falling under the attacks of the northern barbarians, the use of common glass for lighting purposes was extended. A small pane in a bronze frame may be seen at Pompeii, and fragments of window-glass have been picked up from the ruins of Roman villas elsewhere. Glass of this kind was cast on a stone, and was usually very uneven and full of defects; and though it was capable of transmitting light, it must have allowed only an imperfect view of external objects. Very likely this defective method of manufacture was one of the causes why the builders of the early Christian churches adapted the lovelier mosaic work in colored glass for the purpose of lighting and beautifying their sacred edifices. Thus was evolved the magnificent windows of stained glass that still glow with jewel-like splendor in Chartres Cathedral, showing to what height of beauty the glaziers of the thirteenth century attained.

The secrets of glass-making dearer to the Venetians than life itself

Alongside this lovely development of glass-making, there continued, chiefly in Venice, the more ancient traditions of the art of making exquisite table-glass and other vessels of use and beauty. Like the Sidonians, the glass-makers of Venice carefully guarded the secret processes by means of which they obtained a practical monopoly of fine glass-work. If any workman transported his craft into a foreign country, an emissary was sent by the state to assassi-

ARTISTIC GLASSWARE OF 1000 YEARS


Rock crystal ewer, Italian, sixteenth century


Glass bowl with cover, Venetian, sixteenth century


Vase, Roman, fourth century


Wine-glass, Venetian, sixteenth century


Goblet, Venetian, sixteenth century


Examples of English table glass made in the twentieth century that rival the ancient in beauty.

SPECIMENS OF BEAUTIFUL WORK IN GLASS FROM A WIDE RANGE OF TIME AND PLACE

FROM SHAPELESSNESS TO SHAPELY BEAUTY

We here see the potter contemplating a shapeless lump of clay on his wheel. He can mold it at will into innumerable forms.

By the use of his hands alone, and the swiftly turning wheel, he is shaping the lower part of a vase, using at once inside and outside pressure.

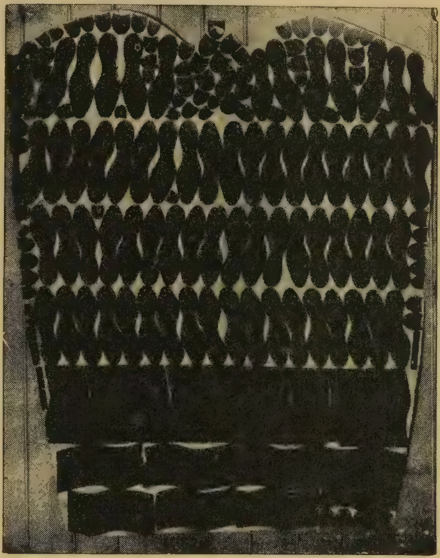
The vase grows under his clever hands until it takes an ewer-like form, but this is only a passing stage.

Here by the delicate measurement of eye and hand the clay has been transformed into a graceful vase.

Until a few years ago the shoes worn by the different classes in our modern society were almost as significant of the social positions of the wearers as were those of the ancient Egyptians. In the United States, however, shoe-machinery and chemical tannage of leather gave a democratically uniform appearance to the feet of the people.

Armed with labor-saving and labor-cheapening machines and his new chemical processes of leather-making, the American sailed across the Atlantic bent on supplying Europe with his well-shaped and smart-looking shoes. Instead of producing a few stock sizes, as was the custom of European manufacturers, he used pattern lasts for practically every shape of foot. Small variations in width and length, and combinations of these variations, enabled him to fit every customer with a cheap shoe that was almost as well molded upon the foot as if it had been hand-made to measure. American boots and shoes ousted the plain and cumbersome product of foreign designers and manufacturers who were not able to withstand the invasion. Thus the shoe trade of Europe was revolutionized by American inventive genius; although, due in great measure to further improvements of tanning processes by English scientists, the industry in Great Britain has also undergone a remarkable development from within.

Originally the small tanners depended for hides upon the surrounding country, but with the advent of the railroad and the steamship, and the application of chemical science, the tanner of today is dependent

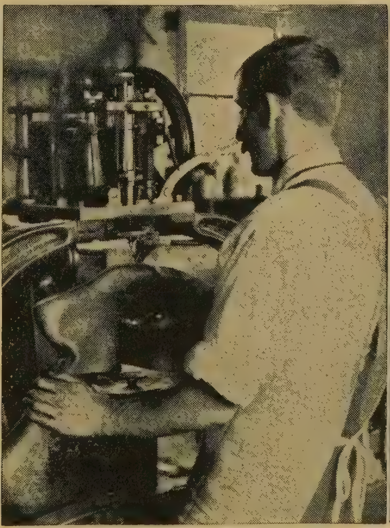


A TANNED SKIN CUT UP FOR SHOES

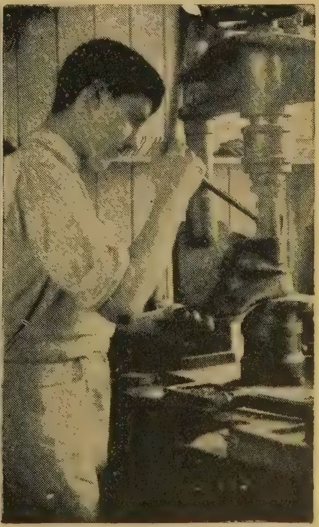
There is no waste in the boot and shoe industry; every fragment left between the shapes cut out is used in making up the heels or is worked up into a composition.

upon no one country nor any special animal for his raw material. The heavy hides are obtained from oxen, cows and horses, while the lighter ones come from calves, sheep, goats, deer, pigs, seals and from various fur-bearing animals whose pelts usually retain their hair after tanning.

ATTACHING THE SOLES



STITCHING ON THE SOLES



FIXING ON THE HEELS

These are generally made by grinding the stalks wet, allowing the fermentation to take place after grinding, mixing with various salts, scenting, and moistening to the desired degree. Though once the most popular and fashionable manner of using tobacco, snuff-taking now falls far behind the other forms of indulgence in the weed. Yet it still claims its votaries and doubtless always will.

Cigars constitute a most important form in which tobacco is consumed for smoking, and up to about 1895 made up the largest aggregate of tobacco consumption in any form. The cigar is of Spanish or Spanish-Colonial origin, and it was long used in Spain before its general adoption in other countries. The greatest skill in the manufacture of cigars has always been shown by Spanish or Cuban artificers, and Havana has been the seat of the best manufacture for more than a century. Leaves for cigar-making must be of a good color and fair body, possess a pleasant aroma, emit an agreeable odor on burning, have a fairly fine texture, a certain amount of toughness, the ribs and veins must be small, and finally they must answer the burning test, which is that the leaves should continue to smolder after they have once been lighted. The wrapper must be of elastic leaf, so applied as to form a perfect ovoid cylinder, one end of which is closed and the other open. Uniformity in size, length, weight and color is essential.

The best cigars, that is, most of the standard brands made by reputable firms to retail for five cents or more, are made by hand and the machine-made goods are those that would be classed as cheroots, little cigars and others of lower price. Cigars are made by hand in quite a simple way. The leaves are stripped of their midribs, smoothed and sorted, the perfect half-leaves being put on one side to be used as wrappers. One of these strips is cut into the shape of a balloon gore, and fragments of imperfect leaves and cuttings, known as the "fillers", being placed at one end, the strip is wrapped around them. Over this is then wound spirally a long narrow rectangular strip of fine texture called the "wrapper", beginning at the lighting end and finishing at the pointed or mouth end. Just a touch of gum of a tasteless and colorless kind on the point where the wrapper is tucked in is used to prevent unwrapping. The cigars are then gauged, cut to length, dried and packed. This is the way in which the best cigars are made. In cheaper and more

Courtesy Liggett & Myers Tobacco Co.

TURKISH TOBACCO IN A NATIVE "MAGAZINE"

Shelves in a typical warehouse in Cavalla, in Thrace. The bales are kept from one to thirteen years mellowing with age. Then they are sent to bonded warehouses in the United States for storage until needed by cigarette manufacturers. It takes a man from four to six weeks to pack a bale, and during the years in storage each bale is frequently turned so that the tobacco will mature uniformly, and the cords around them are tightened weekly, so that the tobacco as it dries will remain closely packed.

quickly made varieties the bunch is rolled in the ordinary way, and then shaped by being pressed into a mold. When set, the bunch is taken from the mold and covered with a wrapper leaf. Molded cigars can usually be distinguished by the two long ridges running their whole length, due to the bunch wrapper being slightly caught between the two sections of the mold when pressed together. Cheroots differ from cigars only in the matter of shape, being open at both ends, generally with one of them much broader than the other. Good cigars should consist of the same material throughout but very often a seductive wrapper conceals an inferior filler. Cigars are rarely adulterated; the filling is at worst nearly always tobacco of a cheap kind. Cigars are often tied, while

LIMPID WATERS FROM THE SNOWY HILLS

LAKE IN GLACIER NATIONAL PARK

FACING PAGE 2593

Power

THIS is the division of our book which deals with the forces of nature man has been able to draw upon to do the work his own hands cannot accomplish. Here we can give only the titles of the chapters (in heavy-face type), and a word or two as to what they are about, to indicate how absorbing the subject is and how constantly it enters into everyone's daily life. From the building, heating and lighting of our homes, the daily transportation, private or public, to our office or factory, the instant communication between the two whatever the distance, by wire or radio, the machines that with almost human intelligence accomplish these miracles, the entertainment of our evenings with picture or music, the very preservation of the sound of our voices or of the appearance of our features in permanent record, all these and much beside go to make up this story of the triumph of mind over matter.

A Jet of Steam
Resembles a crowd leaving a ball game
Its velocity—how great? how acquired? how utilized?
The action of steam in utilizing its internal energy

Seeing the Hitherto Invisible
The chief instrument of modern science
How the microscope reveals a new world of life and movement
The scales in a speck of dust from the wings of a moth

The Sun as an Artist
The advance in the art of photography
The convenient Kodak makes everyone a photographer
How color filters and color-sensitive emulsions are used

Things Seen as they Are
Revelations of the cinematograph
What the movies do and what they could do
The interesting and pleasing side of Hollywood

Machines that Talk
Speech reproduced by steel wire
How living singers may delight future generations
The use of talking machines in business

The Chemist as Creator
Probing the mysteries of life
Combining elements to outrival living Nature
What may we not hope from the synthetic laboratory?

Cellulose and its Many Uses
Another marvel of the creative chemist
Its surprising products, from paper to sausage casing
Remarkable relative mechanical strength, as compared with weight

The Mightiest Force
The weapon of death a source of life
A power that removes mountains and drops destruction from the skies
The sword of war beaten into the plowshare of peace

Chemical Warfare
Preparedness the best preventive of war
Some of the lessons the Great War should have taught us
Recent and future new terrors of warfare

Tunneling the Earth
Mountain, sea and city undermined
Boring through incredible obstacles new avenues for traffic
"Cut and cover" methods in subway construction

The New Electric Age
The universal servant of mankind
The leading part that electricity plays in modern civilization
Generating, storing, utilizing electrical energy

Power over Darkness
The cheapening of artificial daylight
How the Great White Way now reaches round the Earth
The battle between gas and electricity

How Cold Conquers Decay
The triumph of refrigeration
Food preservation against heat and microbe
The making of artificial ice ashore and afloat
How they harvest and store natural ice

The Fight against Fire
The millions yearly lost—and saved
A city peril that increases with growing population
Modern buildings fire-resisting rather than fire-proof

The Marvels of Speed
The speeding-up of the human machine
How speed records never stand unbroken long
Projectiles in flight unseen by human eye caught by the camera

The Marvelous X-Ray
The magic tube of modern science
Breaking up the atom and discovering a new power
How the Röntgen rays aid the surgeon and the nurse

Modern Weather Wisdom
How storms are traced over land and sea
How we know it is going to be "fair and warmer"
Kite and balloon-raised self-recorders

Guarding the Mariner
Lighthouses both ancient and modern
The twinkling lights that help the sailor find his way
Buoys and light-ships, foghorns and sirens

Present-Day Warships
The last line of our naval defense
The monster floating fortresses that cost millions
Their test in modern naval battles

Submarines and Torpedoes
Recent wonders of under-sea navigation
The "eyes" and "ears" and sting of the submarine
Exploits courageous, and achievements, commercial

Measurements of Time
How the flying hours are marked
From the age of hour-glass, candle and sundial to that of clocks

THE AËRIAL FLIGHT OF MAN

How He Can now Fly much more
Swiftly than the Bird He Copied

THE WONDERFUL DEVELOPMENT OF AËRONAUTICS

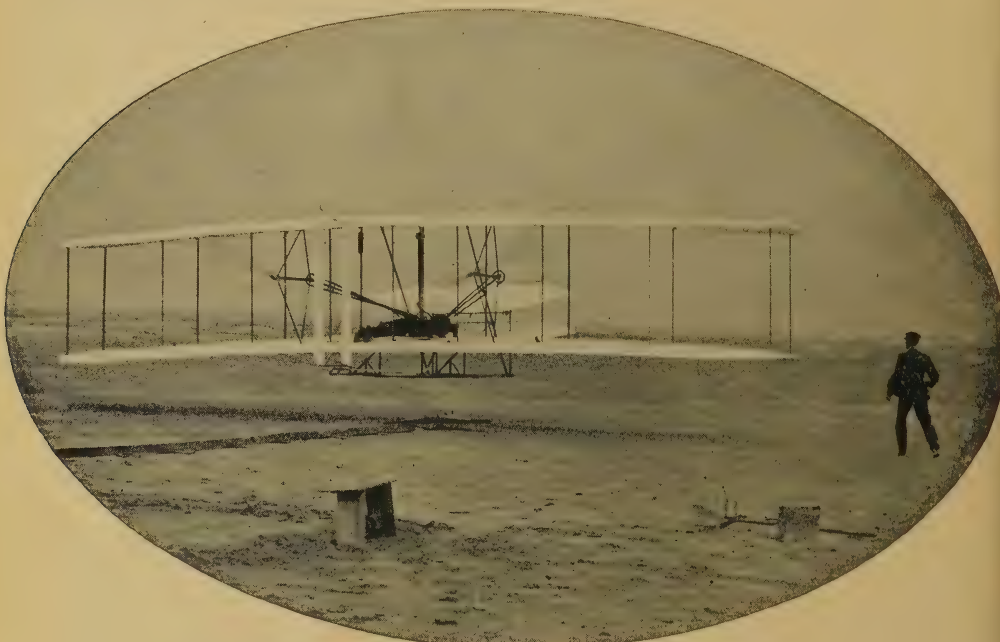
THERE is no branch of science which has shown a more remarkable growth during the past ten years than that which pertains to the navigation of the air. It is less than a generation since the first mechanical flight was made, yet, in that brief space of time, the airplane and dirigible balloon have come to be accepted as commonplace vehicles, having their place and their uses just as have the street railway and the automobile. Such feats as the transatlantic flights and the regular carriage of the mails by airplanes have been performed and are slipping back into the realm of the commonplace. As for the military uses of aircraft, the extension of combat to the air has almost revolutionized the practice of the art of war, and for a nation to undertake war without an extensive aërial equipment would be utter madness. The general who lacks air scouts is in the position of a man who attempts to play a game blindfolded against an opponent who suffers under no such handicap.

Various attempts to solve the problem of flight are recorded in mythology and in the history of the Middle Ages, perhaps the most important having been made by the Italian artist and scientist, Leonardo da Vinci. The most that any of these experimenters was able to accomplish, however, were short and unstable glides. The majority of them failed through a too slavish imitation of nature, the effort always being made to copy the wings of a bird. First among those whom we may declare to belong to the modern period of experimentation was an Englishman, Sir George Cayley.

In 1796 Cayley made a number of toy helicopters, or machines with directly lifting screws and no wings, and tested them with interesting results. The motive power was furnished by the elasticity of a bent piece of whalebone. As it was apparent that this did not furnish a satisfactory means of navigating the air, he turned to another method, and, more than a hundred years ago, produced a very accurate analysis of the forces which the wind exerts on a flat plate. He also showed the advantages of a curved wing section with a sharply dipping front edge. With this as a basis, he actually designed and built an airplane not very different, in its fundamental characteristics, from the machines in use today. We are told that this machine, when released at the top of a hill, would glide forward and land in the valley below, descending on a slope of about 8 degrees. Also, when a man ran forward on level ground carrying the machine with him, he would often be lifted into the air and soar for short distances. Cayley, however, like all the other early workers, was hampered in his tests by the lack of an engine. When Boulton and Watt brought out their steam engine he seized on it with avidity, believing that it offered the road to mechanical flight, and he has left calculations showing that such an engine would weigh 163 pounds per horse-power. Sir George never proceeded to the point of actually equipping an airplane with an engine. In addition to formulating the first principles of aërodynamics and investigating the steam engine, he prophesied the advent of the lighter internal combustion engine.

While this idea was not wholly original, their practical use of it was what set the Wright brothers on the road to success. After conference with Mr. Chanute, they built another glider in 1901, and another in 1902, each being an improvement over its predecessor. In the 1902 machine they used a movable vertical rudder for the first time. The Wrights' gliders were all characterized by the fact that the operator lay flat on the lower plane, instead of hanging suspended below it. They learned, too, after their adoption of the vertical rudder, that the rudder and wing warping must be operated in conjunction to obtain the best results. This simultaneous use of the two controls was the really vital feature of the Wrights' invention, and, having thus attained satisfactory balance, and having secured adequate practice by the making of over a thousand glides, they deemed themselves ready to undertake the construction of a power machine.

The brothers accordingly returned to Dayton and began the construction of a 16 horse-power engine, which they applied to an enlarged replica of one of their gliders. When the machine was finished they took it to Kitty Hawk, N. C., where all their gliding experiments had been performed, and there, on December 17, 1903, Orville Wright left the ground, making a perfect flight of 59 seconds' duration. Progress from that point was slow, but certain, and two years later both Orville and Wilbur Wright were making flights lasting over half an hour. The era of doubt was over, and human flight was an accomplished fact. During the next few years machines sprang into the air literally by the dozen.



Courtesy of *Flying*

ORVILLE WRIGHT MAKING THE FIRST FLIGHT, DECEMBER 17, 1903

The first man to really fly in Europe was Santos Dumont, whose biplane made several short flights late in 1906. During the following summer, Henry Farman, using a Voisin machine, made a flight of about a mile, and in September, 1908, Farman made a flight lasting 45 minutes. His triumph was brief. The records of the Wrights had not received much credence in Europe, but, in October, 1908, Wilbur Wright took his machine to France, and before the end of the year he had silenced the doubters by remaining in the air for 2 hours and 20 minutes continuously.

A ZEPPELIN AIRSHIP SAILING OVER LAKE ZURICH

FACING PAGE 536

A JET OF STEAM

Its Velocity — How great?
How utilized? How acquired?

RESEMBLES A CROWD LEAVING A BALL GAME

THE wheel of a De Laval steam turbine runs at about thirty thousand revolutions per minute, which, if the wheel is 6 inches in diameter, makes the velocity of the ends of the turbine blades about 780 feet per second. As the speed of the blades is about one-half that of the steam driving them, this means that the jet as it leaves the nozzles just before hitting the blades must be traveling at a velocity of about 1500 feet per second.

It can easily be shown that if steam is taken from a boiler at high pressure and is permitted to expand freely through a nozzle down to a pressure of one pound per square inch it will develop, if unopposed, a velocity of 3000 to 4000 feet per second or from 35 to 45 miles a minute, depending upon its initial condition.

This velocity is so tremendous that it cannot be utilized in a single turbine wheel as it is not safe to run turbine wheels as fast as one-half this velocity for fear they would fly apart. Turbines of this type are, therefore, used only for small pressure ranges which give relatively small jet velocities.

The best way to appreciate how great is the velocity of a steam jet is to compare it with velocities developed in other ways. The following table contrasts the velocity of the steam jet with the velocity of water jets, of steam through pipes, of trains, of falling bodies, and of bullets leaving the nozzles of various rifles, of molecular vibrations, of the movements of celestial bodies, of ether vibrations, etc.

TABLE OF VARIOUS VELOCITIES

	Feet Per Second	Miles Per Minute
Steam trains	30 to 100	0.3 to 1.2
Steam through steam pipe	100 to 200	1 to 2
Water from nozzle under 100-ft. head	80	.9
Dart dropped from airplane one mile in air (mighty air friction) at moment of striking	580	6.6
Sound wave through the atmosphere	1100	12–13
Equatorial velocity of earth due to daily rotation	1520	17.3
Bullet from sporting rifle	2500	30
Bullet from German rifle (Mannlicher)		
Maximum velocity	3750	45
Ordinary velocity	2750	
Bullet from Canadian rifle (Ross)		
Maximum velocity	4200	47¾
Ordinary velocity	3150	
Saturated steam expanding through nozzle from 250 lbs. to 1 lb.	4200	47¾
Superheated steam from 600 lbs. and 625° F. to 1 lb.	4700	53.4
	Miles Per Second	
Body falling from space upon moon due to moon's attraction	1.7	102
Probable maximum velocity of molecules at 32° F.		
Carbon dioxide	1.6	96
Oxygen	1.8	108
Nitrogen	2.0	120
Water	2.5	150
Hydrogen	7.4	444
Body falling from space upon earth due to earth's attraction	7.3	438
Average velocity of earth about sun	19	1140

THE USEFUL WASTE

How Cheaper Power is Being Won and
Untold Riches are Extracted from Waste

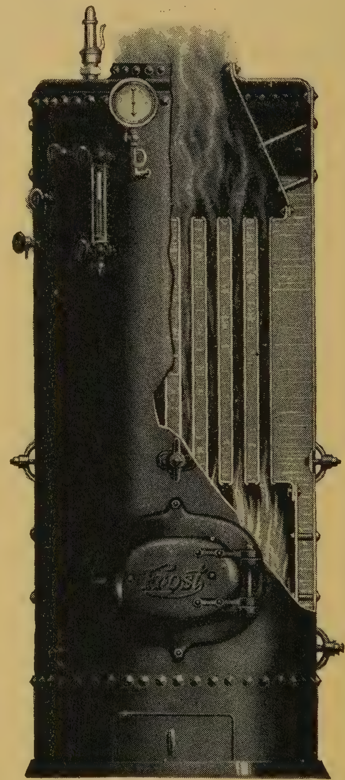
VICTORIES OF ENGINEERS AND CHEMISTS

AS civilization advances, population presses on the means of subsistence, and a sense of the folly and sinfulness of waste is awakened. Not only is the fact of the waste itself mournful and reprehensible, but the disposal of the wasted products themselves is costly and often offensive.

Waste may be very broadly grouped under two heads. One is that of power agencies, the other the by-products thrown out in the preparation of primary products. The waste gases from iron-furnaces, the coke from gas-retorts, the refuse of cities, and the inferior fuels are familiar examples of the first. Illustrations of the second are the by-products and wastes of chemical and other industries which are not sources of power.

Heat is the primal agent of power—heat derived from coal and held in the grip of steam; heat stored up in gas derived from coal, and oil and waste fuel; and that surplus heat much of which passes the wit of man to utilize. Although the amount of coal that is now used to yield a horse-power is only from one-sixth to one-eighth of the quantity employed a hundred years ago, the waste is still appalling.

Let us consider more in detail the question as to the power wasted when the heat energy of steam is made to do useful, mechanical work. The first steam boilers were simply hollow shells partly filled with water, so that an application of heat to the exterior of the shell would heat and eventually vaporize the water. These boilers were, of course, very inefficient and wasteful and they were later improved by introducing a large number of tubes into the water space and causing the hot gases to pass through these tubes. These were called "fire-tube boilers" and gave much



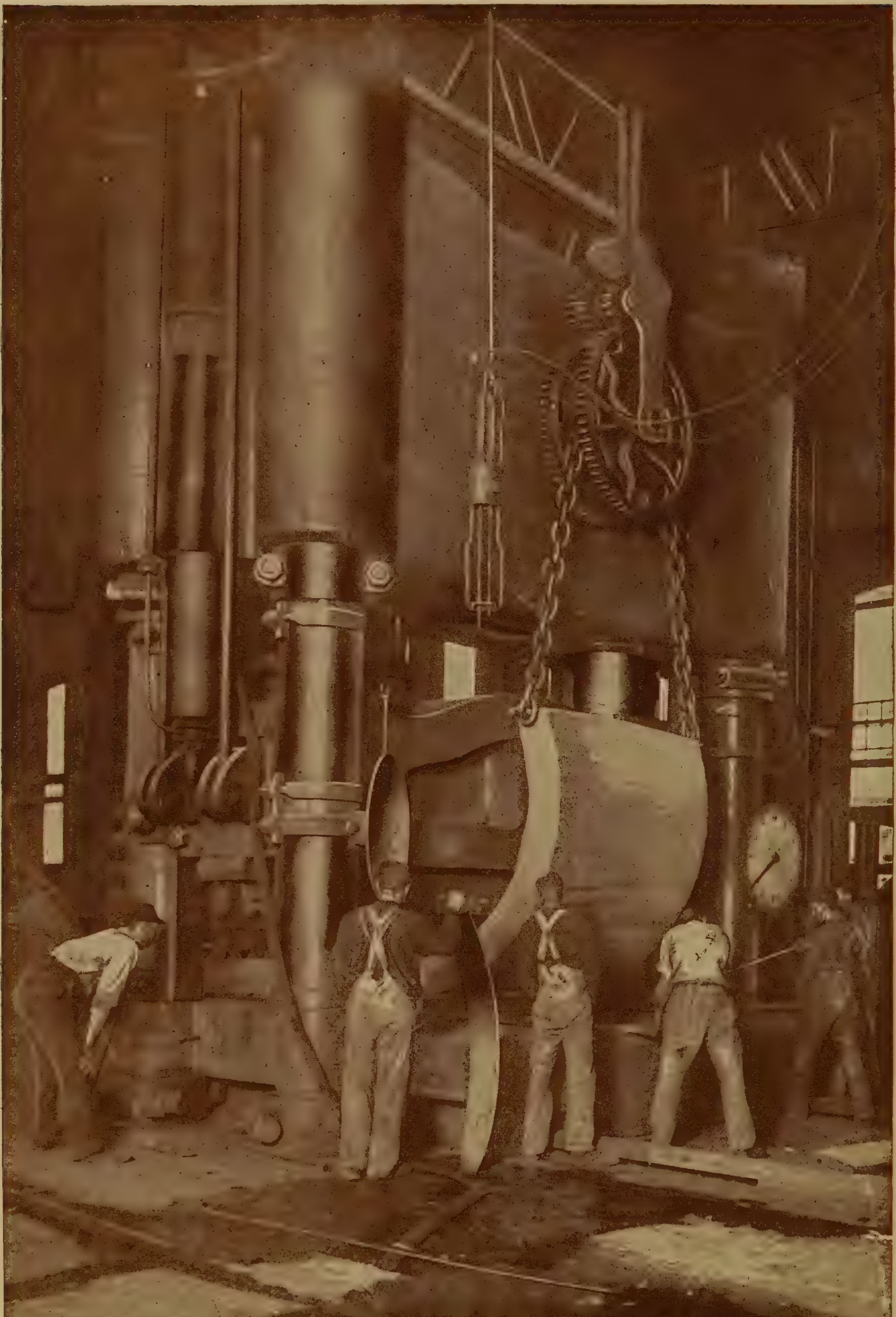
Courtesy The Frost Mfg. Co.

VERTICAL FIRE-TUBE BOILER

The waste elimination is decreased and the efficiency of the boiler made greater by increasing the heating surface through the use of fire-tubes which divide the water space as shown in cross section.

better results. This type is well illustrated by the accompanying sectional view of a vertical fire-tube boiler. Other improvements came later and these will be taken up in a subsequent chapter.

WHAT THE PRESSURE OF WATER CAN DO



A BENDING-PRESS CAPABLE OF EXERTING A PRESSURE OF FOURTEEN THOUSAND TONS

POWER FROM LIQUIDS

Utilizing the Vast Stores of Energy
That are to be Found in Petroleum

HOW THE DIESEL OIL ENGINE WORKS

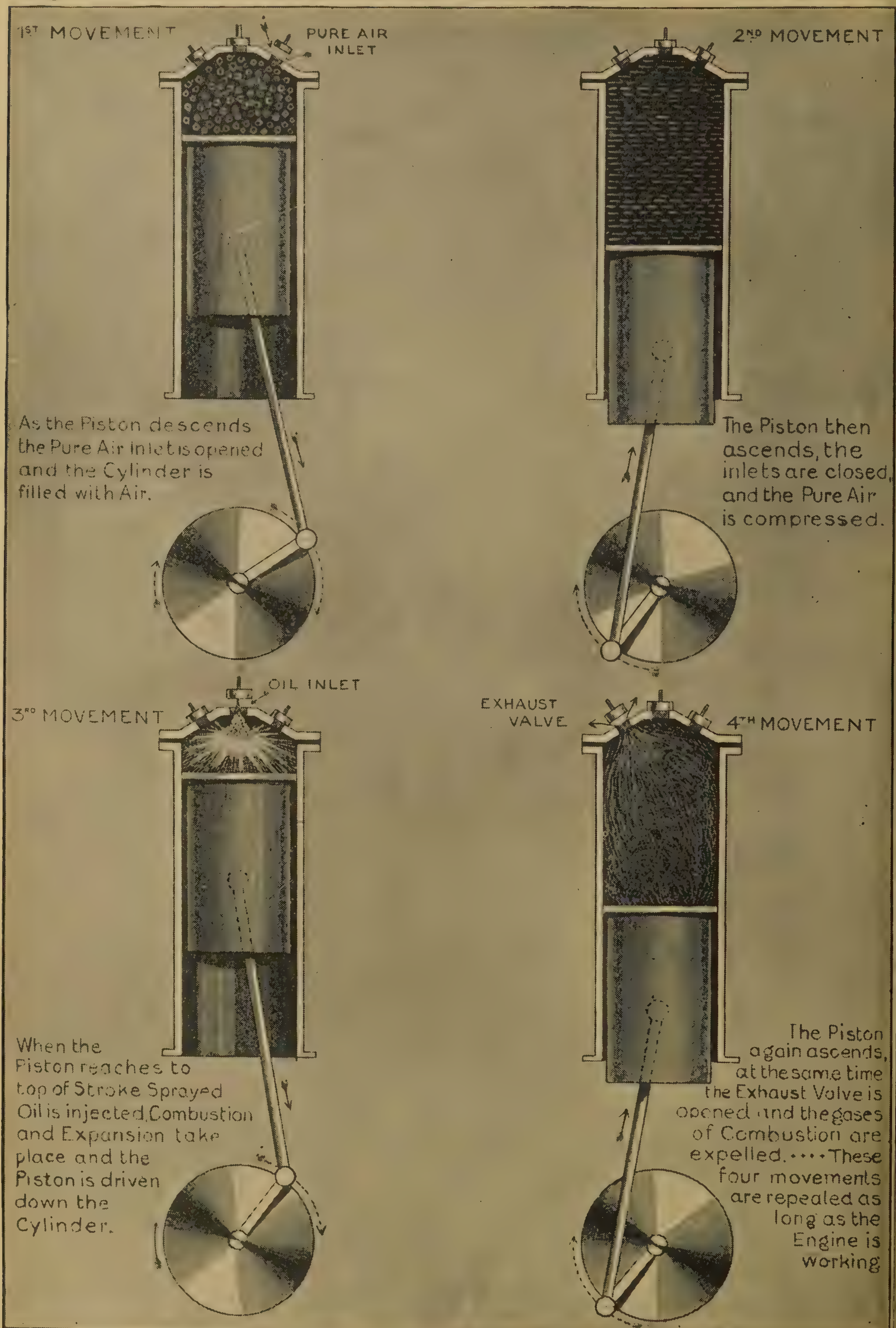
PRECEDING chapters have told how solid fuels may be transformed into useful work either by burning them directly under steam boilers, or by passing them through gas-producers and thus transforming them into combustible gas. It remains to consider how power is obtained from petroleum and its constituents and from such liquids as alcohol and other fluid hydrocarbons.

When crude petroleum is heated it gives off compounds of hydrogen and carbon, or "hydrocarbons", as they are commonly called. Coming off as vapors, they are condensed and form gasoline, benzine, naphtha, kerosene, fuel-oil and other liquids of a similar nature. The compounds separate from the crude oil in a regular order according to the temperature applied to it, the lighter gasolines coming away first and the heavier kerosene and fuel oil coming later. After these are separated a still higher temperature is applied and lubricating oils are distilled and condensed. Crude oils vary considerably, depending on the area from which they come, and a great variety of gradations can be made in the products obtained from a given crude oil by altering the temperature of distillation. An accompanying diagram shows in a graphic manner the sequence in which the constituents of crude oil are separated into groups by distillation.

Petroleum and its several products are the best known forms of liquid fuel in this country. Distillates made from wood, and vegetable products of an alcoholic nature have been used with success and no doubt these will be more widely used as crude oil becomes scarcer and dearer. Fuel alcohol can be made from a wide range of vegetable products but as yet it cannot compete with the distillates of crude oil. In Europe benzol, which is a distillate from coal tar, is much used and will, in time, be found of service on this side of the water. All of these liquid fuels contain hydrogen and carbon and, if vaporized and mixed with the proper proportion of air, they burn readily. The lighter kinds, such as gasoline, are so highly inflammable when mixed with air as to be explosive in character, while the heavier compounds burn much less readily and are much more difficult to vaporize.

All liquid, like solid, fuels, must be first converted into vapor or gas before they can be burned in a gas engine. The lighter distillates, such as gasoline, naphtha, etc., are easily vaporized; in fact they will disappear if simply exposed to the air. The heavier distillates, from kerosene down, are more difficult to vaporize and usually require heating to produce this result. Where the liquid fuel is vaporized outside of the engine and fed to it as a gas, the construction of the engine proper and its cycle of operation are usually essentially the same as for any other gas engine. The only difference is in the addition of devices for vaporizing the fuel before admitting it to the cylinder. If the fuel is fed into the engine as a liquid and vaporized inside of it modifications must be made in its constructive features. And in the highest form of heat engine, known as the Diesel type, heavy oils are fed into the cylinder and burned, rather than exploded, the engine working on a somewhat different principle from any of the others.

HOW AIR AND OIL DRIVE AN ENGINE



These simplified diagrams show how the four-cycle Diesel engine works by the combustion of crude oil in compressed air, no firing-spark being needed as in the ordinary gasoline engine.

A NEW ERA IN THE STEAM WORLD

The Greatest Step Forward in the Use of Steam Power since the Days of Watt and Stephenson

HOW THE TURBINE CAPTURED THE WORLD

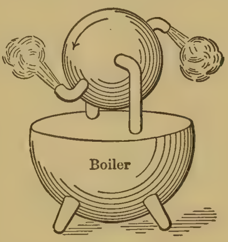
A VISITOR is looking into an engine room containing several large reciprocating engines, each with its multiplicity of moving parts, some rotating, some sliding back and forth and others rocking to and fro. The general impression conveyed to the mind is that of a large collection of complicated moving machinery, dangerous to approach and difficult to keep clean. The visitor crosses a passage and enters a room where the same number of steam turbines are producing the identical amount of power.

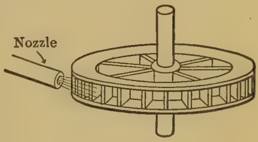
The contrast is startling, to say the least. This room is much smaller and, instead of a great complicated mass of moving machinery, a few box-like affairs made of iron and steel, somewhat cylindrical in shape, are distributed about the floor. The room is very clean and comparatively quiet, the only noise being a low humming which is rather soothing to the ear. At the first glance, it would appear that no moving parts are visible, but on closer inspection, the rapidly revolving shafts catch the eye.

In the first room, a half-dozen men were busily engaged in cleaning and oiling the engines: here, perhaps, two men, with apparently very little to do, but with watchful eyes, are easily taking care of the same amount of power.

These are some of the visible contrasts, and as they appear to be of considerable importance showing up the steam turbine as something in advance of the reciprocating engine, let us look more closely into this new type of prime mover and see how it is able to do the work of the older reciprocating engine to such advantage.

It is interesting to note that the idea of the steam turbine first appeared about 200 B.C., long before any one considered the possibility of using steam in a reciprocating engine. At that time, a Greek named Hero constructed an engine consisting of a hollow sphere mounted at its axis upon two pivots, one of which was hollow and served as a supply pipe for steam coming from a boiler below. The sphere was fitted at the top and bottom with two pipes bent in opposite directions through which steam escaped.





From Hirschfield & Barnard *Heat-Power Engineering*, J. Wiley & Sons

HERO'S STEAM TURBINE   BRANCA'S STEAM TURBINE

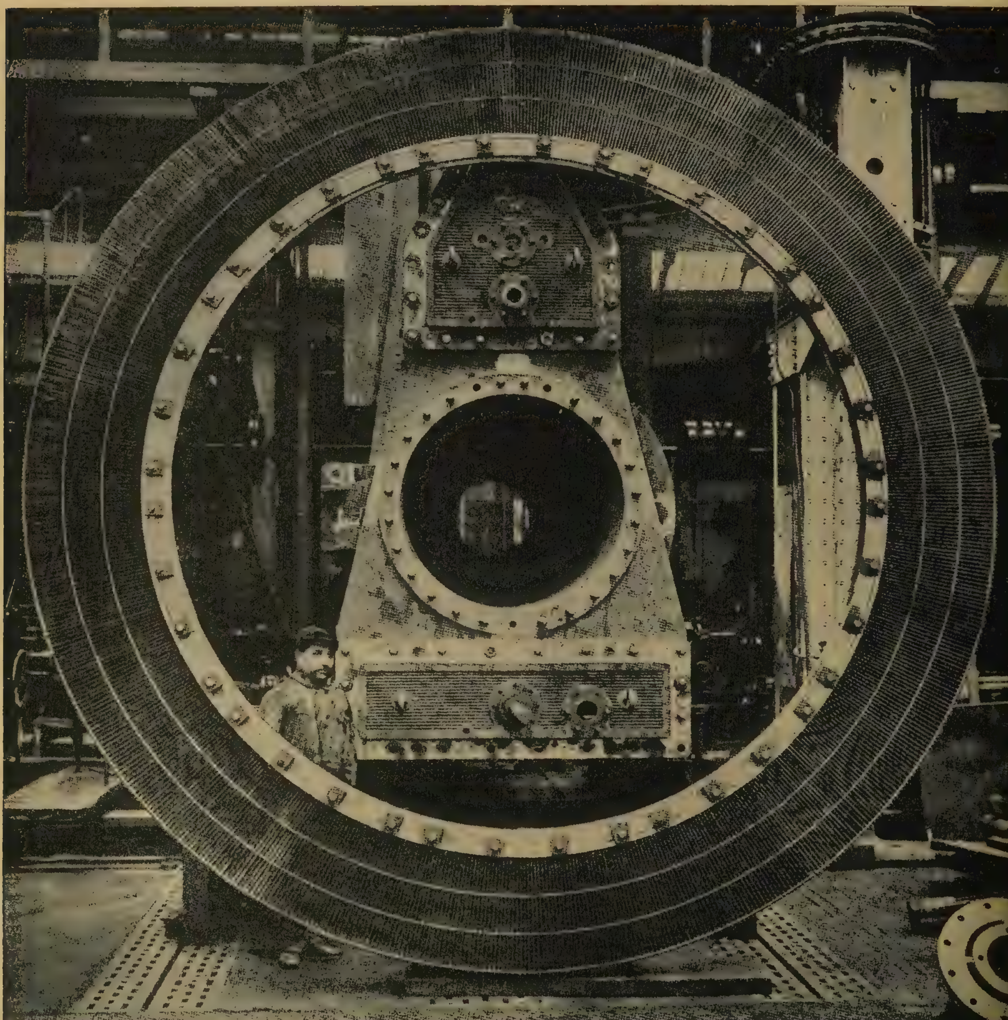
The unbalanced pressure due to the escape of the steam in opposite directions, at either end of and at right angles to an axis, caused the sphere to revolve on its pivots. Unbalanced pressure of this sort is called "reaction." This, therefore, was the first reaction turbine.

Besides the principle of reaction, that called "impulse" is of great importance in connection with the steam turbine. The first impulse turbine was constructed by an Italian named Branca about 1629 and consisted of a wheel to the rim of which buckets or blades were attached. Against the blades was directed a jet of steam, thus causing the wheel to revolve.

balanced, thus producing a more constant speed and making vibration and wear very small quantities. This, of course increases the life of the machine and practically does away with all repairs. The shaft bearings are the only parts of the turbine which need lubrication and this keeps the steam free from oil which is a great advantage when it is returned to the boiler.

While at its rated load, a good turbine will not show any appreciable advantage in economy over a good reciprocating engine, yet if that turbine be run at loads less or greater than normal, it will use less steam than an engine under the same conditions. In other words, its good economy is nearly constant for all loads while that of the reciprocating engine is not.

As to first cost, a turbine alone without its auxiliaries costs less than a reciprocating engine; but taken with the condenser, pumps, etc., there is very little difference between the two. The cost of upkeep, repairs, attendance, etc., is much less for the turbine than for the other engine.

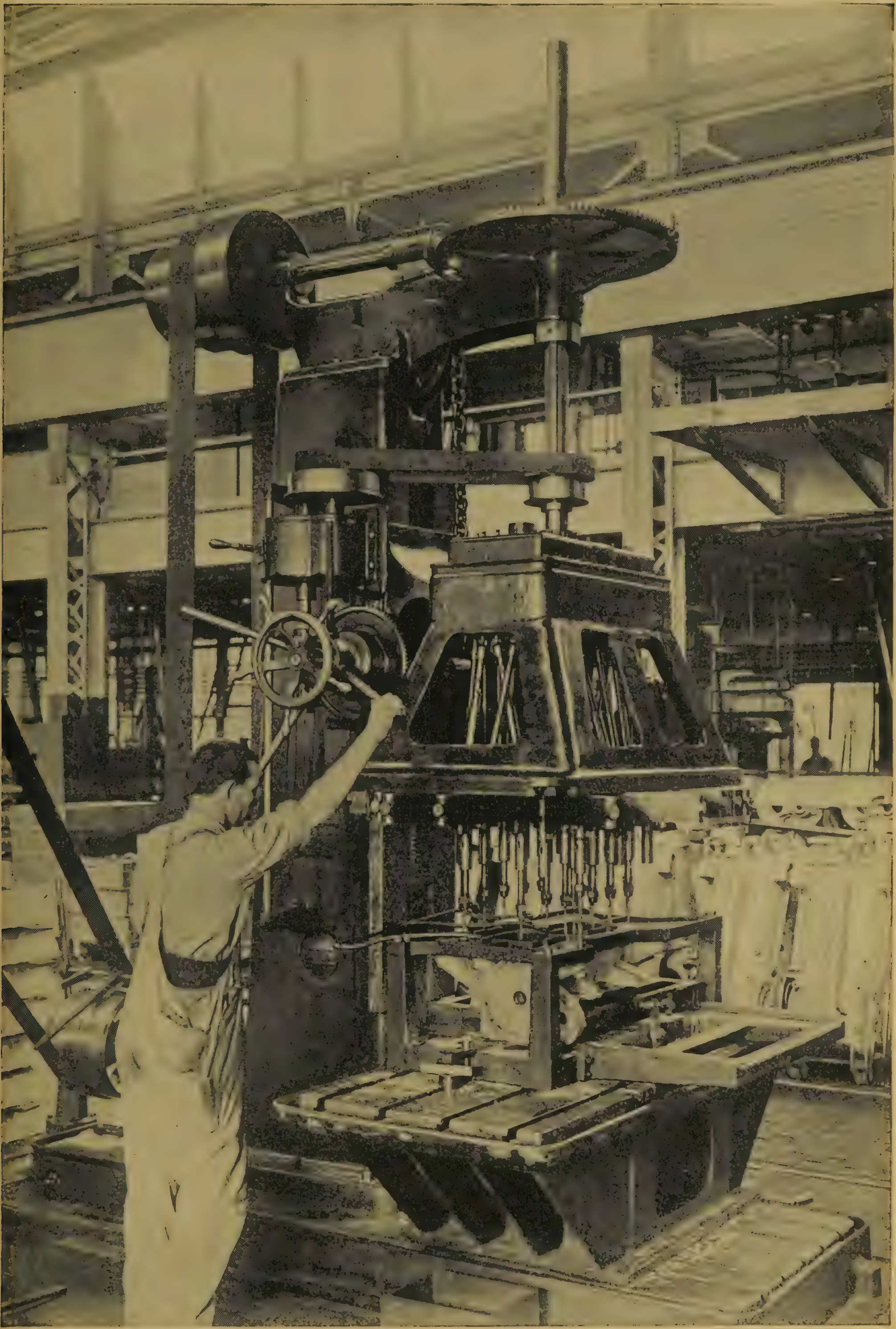


A RING OF THE *MAURETANIA'S* TURBINE-DRUM, WHICH WHIRLS ROUND AT 720 MILES AN HOUR

This shows how wonderfully the little blades are fixed upon the big drum of a turbine, ready to seize the mighty force of the steam that rushes upon them, sometimes as fast as 48 miles a minute, a rate sufficient to go round the world in $8\frac{1}{2}$ hours.

The last few years have seen great progress in turbine design. It has shown itself in new combinations of the different

THIRTEEN HOLES AT A SINGLE STROKE

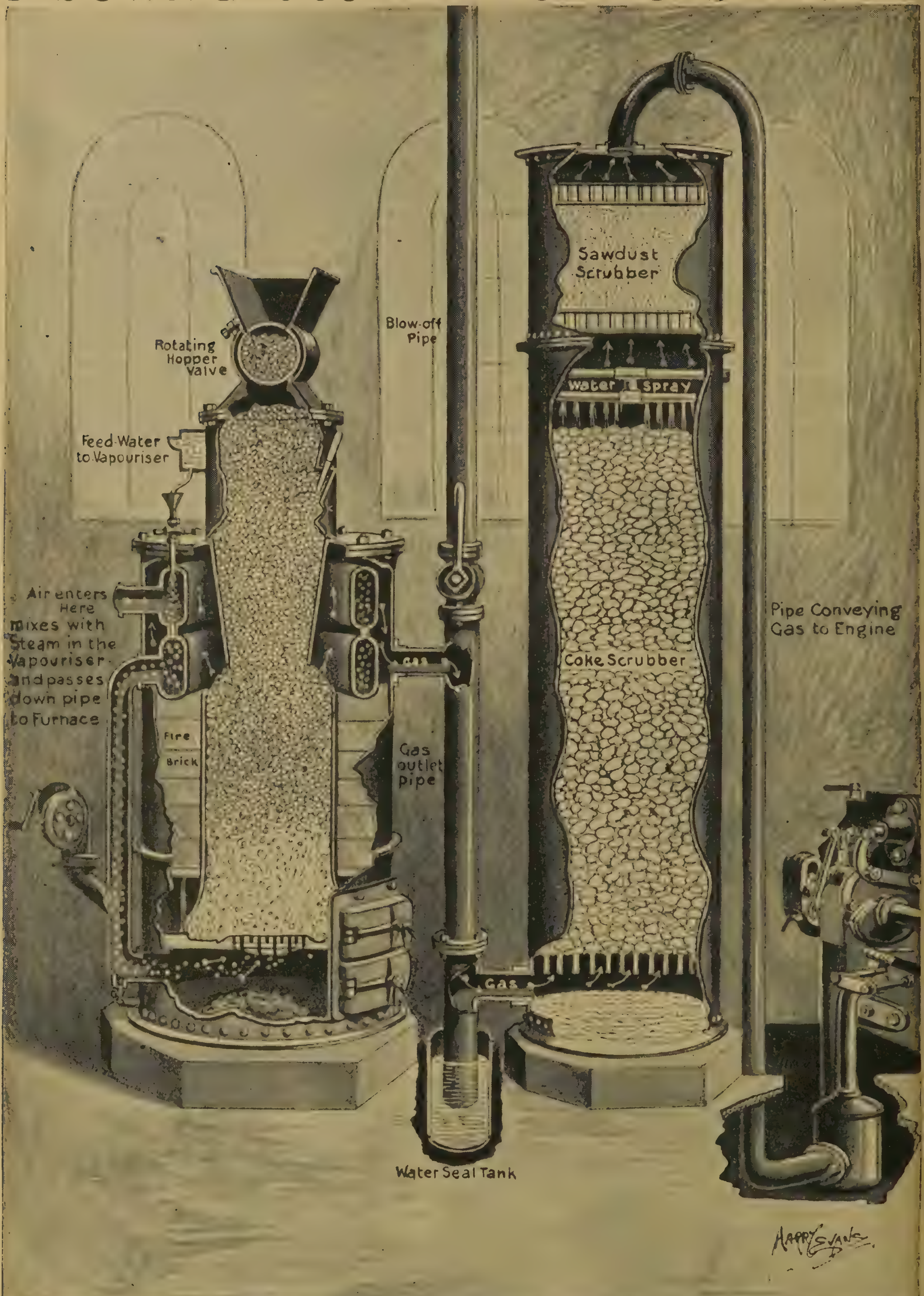


Courtesy Baush Machine Tool Co.

A MULTIPLE-SPINDLE DRILLING MACHINE

Boring thirteen holes of different sizes simultaneously in a base for an automobile engine.

ITS OWN GAS SUPPLY FOR A GAS ENGINE



This picture-diagram of a suction gas producer plant shows the method by which a cheap gas for driving an engine is made in an upright iron cylinder and, after passing through a scrubber containing coke and sawdust which cool and clean it, feeds the cylinder of the engine by way of a small reservoir, which regulates the supply.

POWER FROM GAS

The Marvels of the Transformation of
Waste Products into Useful Workers

HOW GAS PRODUCERS AND GAS ENGINES OPERATE

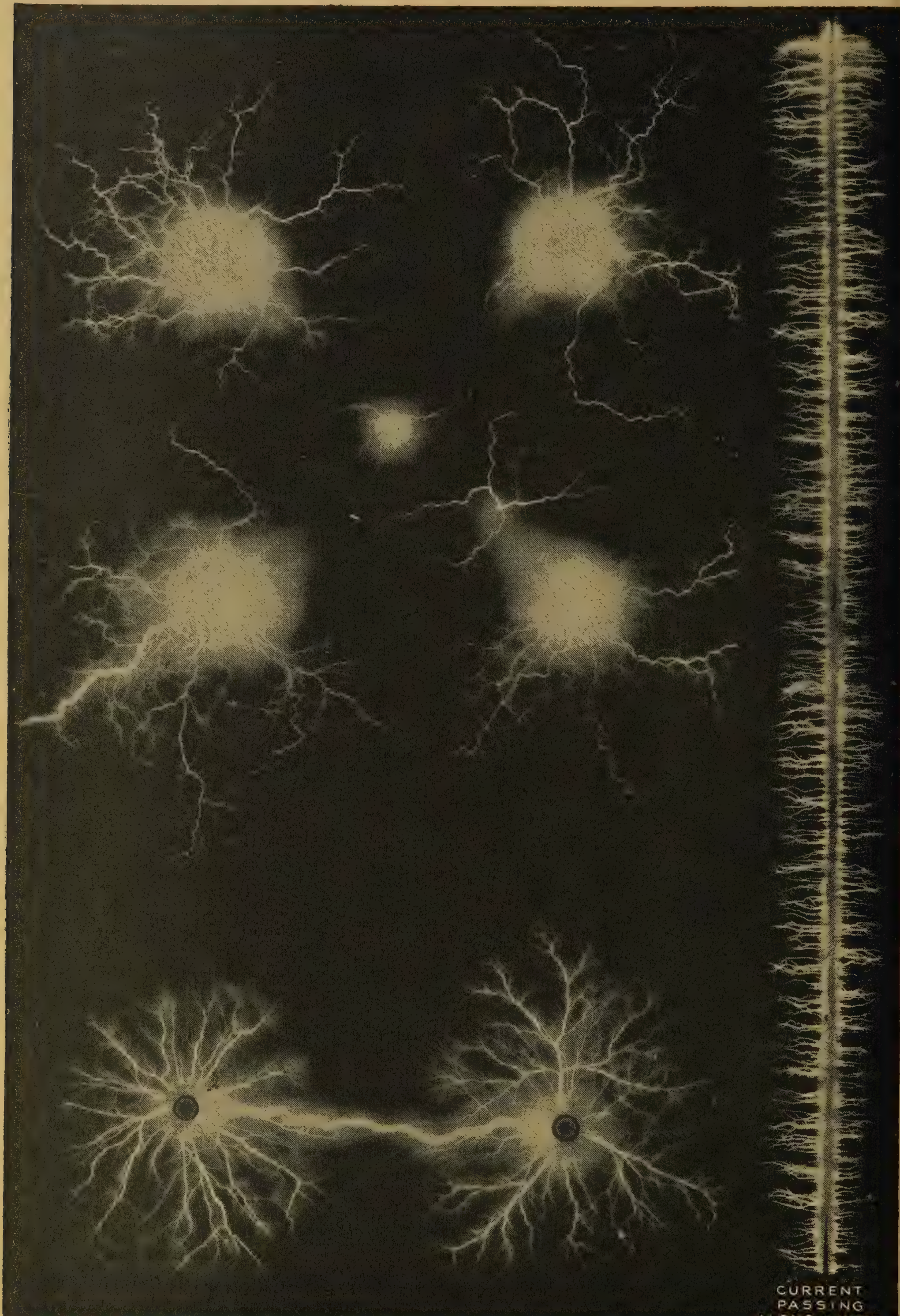
OUR greatest source of power today is heat, and the most available source of heat is the combustion of fuel. Fuels are of many kinds and are either solid, liquid or gaseous. Power is obtained from fuel by using the heat of combustion to expand some medium like steam, air or gas, thereby moving the working parts of some kind of heat engine. Heat engines are divided into two general classes, depending upon the manner in which the fuel is burned. In the first class the combustion takes place *outside* of the engine, the heat being transmitted through its walls to the working medium. Engines of this class are called "external-combustion" engines. The best known example is the steam engine, while another, less well known, is the hot-air engine which uses air as a working medium. In heat engines of the second class the combustion takes place *inside* of the engine and the products of combustion usually act directly upon its working parts. Such engines are known, therefore, as "internal-combustion" engines and are well illustrated by the ordinary gas and oil engines. Obviously the external-combustion engine can utilize solid, liquid or gaseous fuels, while the internal-combustion engine can make direct use only of gaseous fuels or of such liquid fuels as can be easily volatilized; and it is only by first converting them into gaseous form that it can indirectly make use of solid fuels.

But while the external-combustion engine can utilize a wide range of fuels, its efficiency is lessened because of the losses inherent in its method of applying the heat to the working medium.

The best steam plant cannot convert over 16 per cent of the heat of combustion into useful work and an average plant will only convert from 6 to 10 per cent. Such a plant consists, too, not only of boilers and engines, but includes a large number of auxiliary appliances, such as pumps, condensers, economizers, etc., which make it somewhat complicated. A considerable amount of fuel is required to raise steam when starting up, and, if the plant is to be in a state of readiness, to keep up steam even when the engines are not running. Considerations of this kind long ago induced engineers to seek a more direct method of applying heat to the production of power. The modern gas and oil engines are the result of this effort. The best type of internal-combustion engine can convert 35 per cent of the heat of combustion into useful work, while ordinary gas engines can convert from 15 to 20 per cent. As will be seen, the ordinary gas engine plant is much simpler in construction as well as in operation than the steam plant, although larger plants do not always possess a marked superiority in these particulars.

There is no marked difference between internal-combustion engines using gas as fuel and those using gasoline or other liquids that can be readily volatilized into gas. Theoretically and structurally such engines are alike, but those using liquids, such as gasoline, must be equipped with a carburetor or some similar device for volatilizing the liquid on its way to the working cylinder. In engines using crude oil or heavy distillates of crude oil directly in the working cylinder the cycle

A PHOTOGRAPH OF ELECTRIC SPARKS



These are photographs of electric sparks such as are used to set fire to the explosive mixture in an internal combustion engine. They can be made to occur as rapidly as 1200 to 1400 times a minute. These sparks were fixed so that the flashes fell exactly over a photographic plate, and what the eye sees as but a flash is shown to be in reality a thing of remarkable beauty.

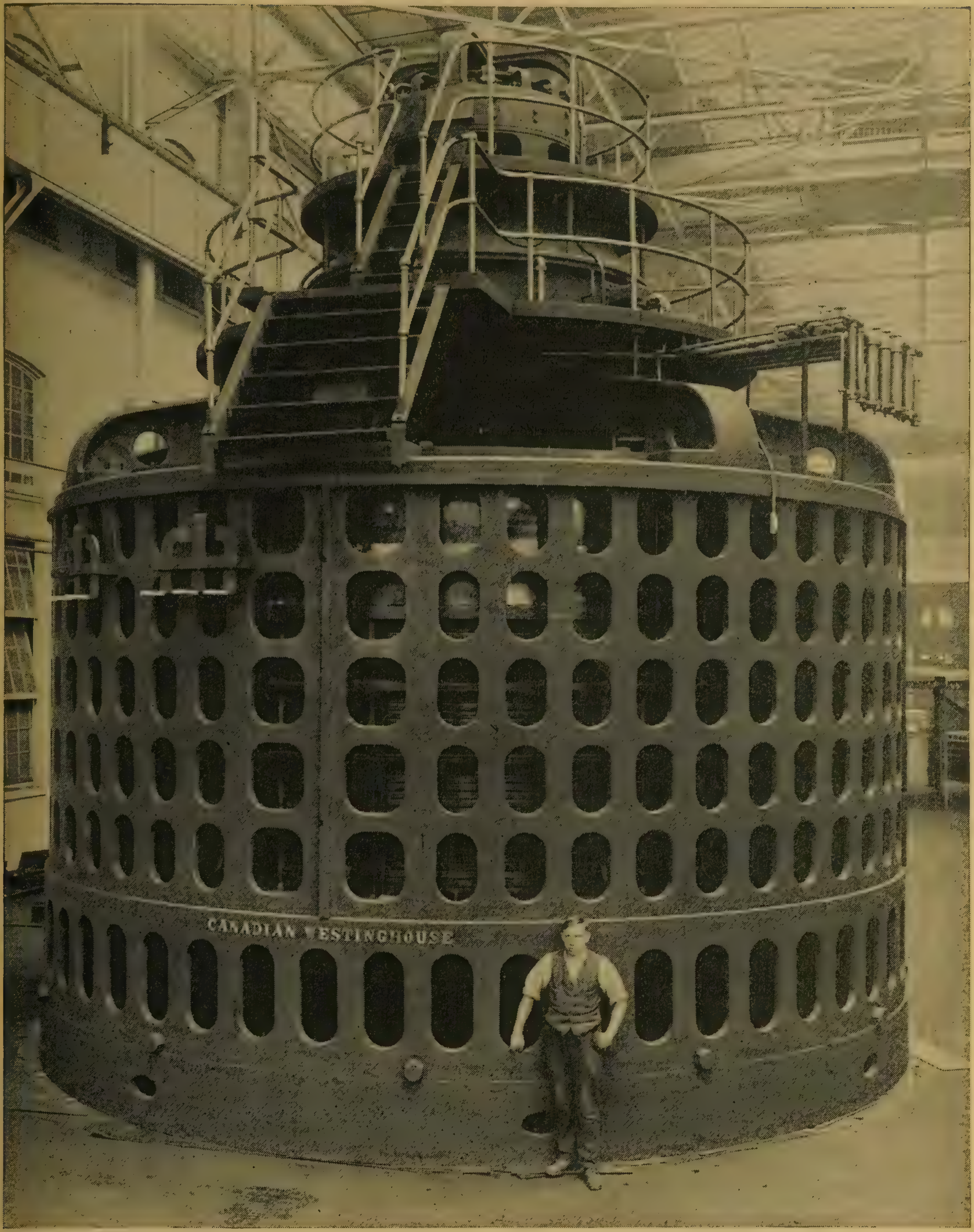


Photo Ewing Galloway, N. Y.

THE LARGEST TURBINE ELECTRIC GENERATOR IN THE WORLD

One of the 55,000 horse-power generators in the Queenston-Chippawa hydro-electric power plant. Turbines of this kind are supported on a cushion of water with such delicate accuracy that, unless braked, it takes twelve hours after the power is shut off for them to come to complete rest.

In addition to the service which electricity renders mankind in driving the machinery of our industrial plants, it may be made to extract the valuable constituents of our mineral deposits for utilization in the arts. The electric current may thus separate pure metal from other materials with which it is naturally associated, a task which in most cases could not be accomplished as efficiently or as cheaply by any other agency. These metals may then be plated in layers of any desired

The man of science, however, is well pleased to study the production of heat in these cases, and to realize that the electricity, or the wax, or the gasoline, means a store of energy which may be turned into light, or motion, or heat, or any combination of these; and that in each and every case the law of equivalence is observed. Just so is it observed when a piece of paper, a check or banknote — which has only potential energy, so to speak — is turned into the energy of motion — only too rapid! — of, say, four pieces of gold, or eighty pieces of silver, or two thousand of "copper," or any combination of these, *provided that* they are equivalent to twenty dollars. Just so, also, the gold and silver and copper, or stamps or what not, may be gathered together again, and transformed into the potential energy of another check equivalent to that for which they were drawn.

So much for the doctrines of the transformation and equivalence of energy. The terms may be a little unfamiliar, but the facts are really simple and reasonable; and we are perfectly familiar with the principle of them in our daily lives whenever we buy anything and wait for the change, or in any process of exchange whatever.

And now we come to the great discovery. Suppose we break our banknote and then decide to turn the change back into a note again, and find that the change is ten cents over or short. We know that something is wrong. We never believe that a dime disappeared by annihilation, nor that a dime doubled itself spontaneously. Either a dime has slipped through a hole in our pocket, or a dime was in the pocket to begin with. Some such explanation there must be. We decline to believe either that a dime became nothing or that nothing became a dime.

If we agree so far, we are indeed prepared to agree with the law of the conservation of energy, which simply asserts about

ELECTRICAL ENERGY IN THE SKIES — PHOTOGRAPH OF A FLASH OF LIGHTNING

All forms of energy are forms of one and the same thing, and can be transformed into one another — light into heat, heat into motion, motion into light. This photograph shows electrical energy in the universe manifesting itself in the familiar form of lightning; some of it turns into sound, but thunder cannot be photographed.

WORLD'S RECORD HIGH VOLTAGE ARC

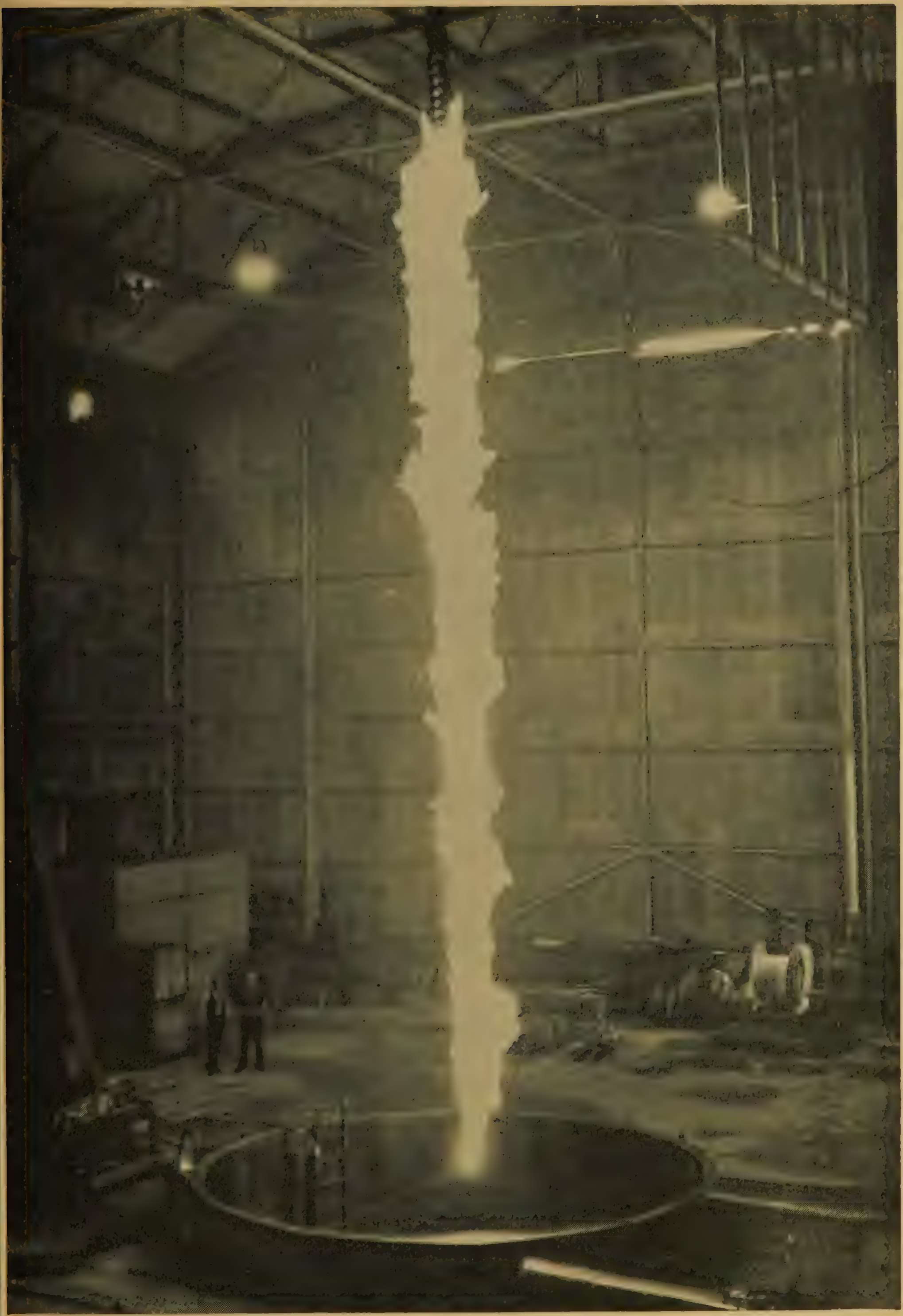
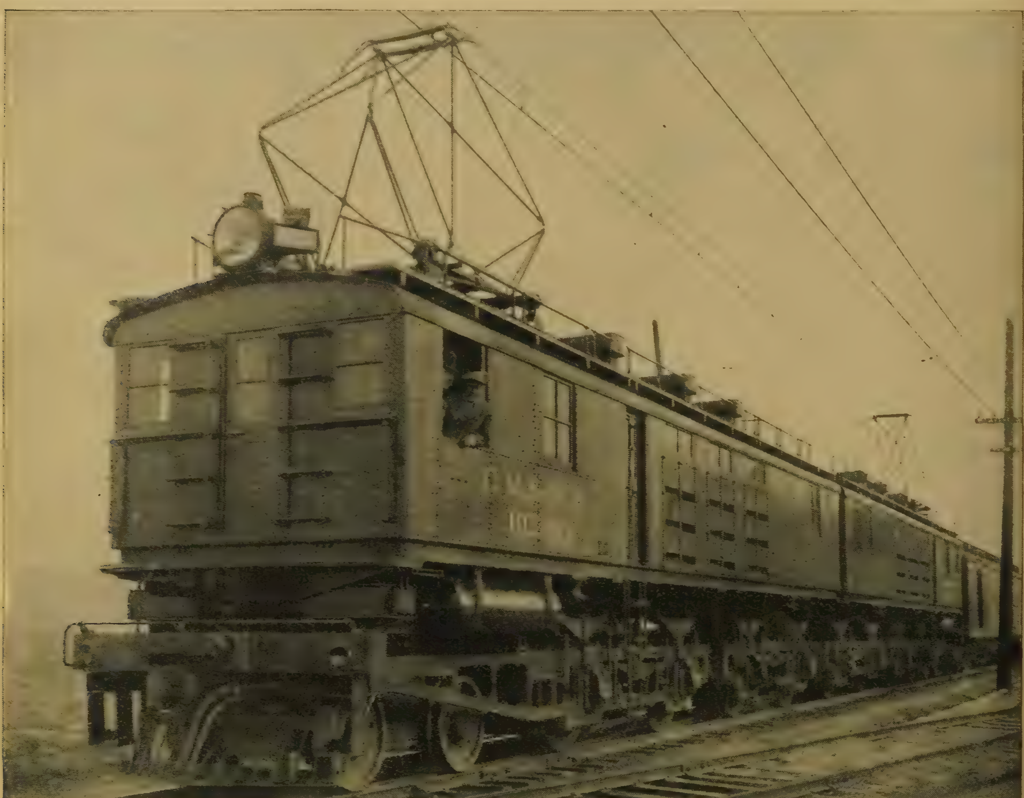


Photo International Newsreel

ARC 55 FEET LONG PRODUCED BY THE HIGHEST VOLTAGE TRANSFORMER IN THE WORLD — A MILLION VOLTS IN A SINGLE UNIT

$56\frac{1}{2}$ miles above six thousand feet; 182 miles about five thousand feet. A grading of 116 feet rise to the mile was permitted, whereas in the Grand Trunk the slope has been restricted to 21 feet per mile. Such curves to avoid supposed difficulties were allowed that later reconstructions have cut off more than a hundred miles of the original route, while at the same time retaining the maximum grade of 21 feet to the mile.



Courtesy of Chicago, Milwaukee & St. Paul Railroad

THE LARGEST ELECTRIC LOCOMOTIVE IN THE WORLD

The "Olympian," electrically operated, starting on its trip over the Rockies. It is drawn by the largest electric locomotive in the world: 3000 horse-power, 112 feet long, weighing 282 tons.

None the less the original American overland route was a great accomplishment, and in the course of it the engineers met and mastered nearly all the difficulties that will be referred to when we sketch the progress of the Canadian through tracks — that is, the difficulties of interposed lakes, rapid streams, strong and weak mountains, bottomless bogs, avalanche-swept slopes and snow-filled cuttings, with the usual lack of labor, and doubt as to adequate capital. In addition, so much harassing warfare with the Indians was kept up that it was said the laying of every tie on the mountain section was at the cost of a shot fired at a lurking foe.

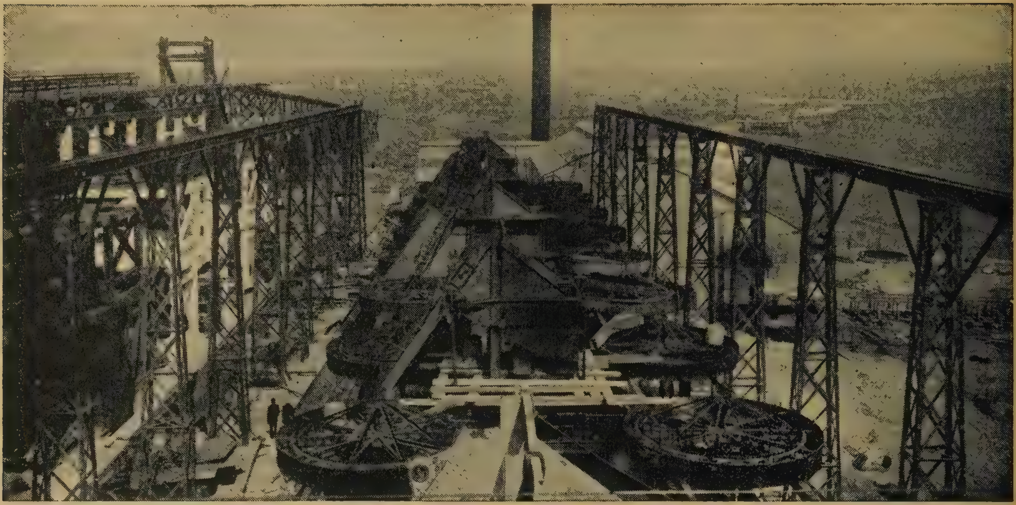
Considering all the circumstances, the distances to be traversed outside of any help from the country through which the construction gangs were passing, and the character of the country to be conquered, one of the greatest railway enterprises heretofore undertaken and accomplished by man has been the Canadian Pacific, joining Montreal with Vancouver. The mere distance of 2906 miles does not even hint at the story. No comparison can be made either with the first American line or with the Grand Trunk, fine engineering feat though it be. For, with the exception of the earlier part of the Grand Trunk, to the north of the Great Lakes, and the later part through the Rockies, this up-to-

Formerly, the lye, or mother-liquor, that remains in the last crystallizing-ponds was allowed to flow back as waste into the sea. But this thick brine is now often run into a shallow pond of beaten clay about an acre in extent. It contains a considerable quantity of valuable chemicals, especially sulphate of soda and chloride of potassium, one of which can be extracted by cold and the other by heat. There was a time when the lye was exposed in winter for the sulphate of magnesia to be deposited, and then pumped up to a covered reservoir, and preserved until the following summer, when the chloride of potassium was obtained by evaporation. But this method is too costly and troublesome to be used today.

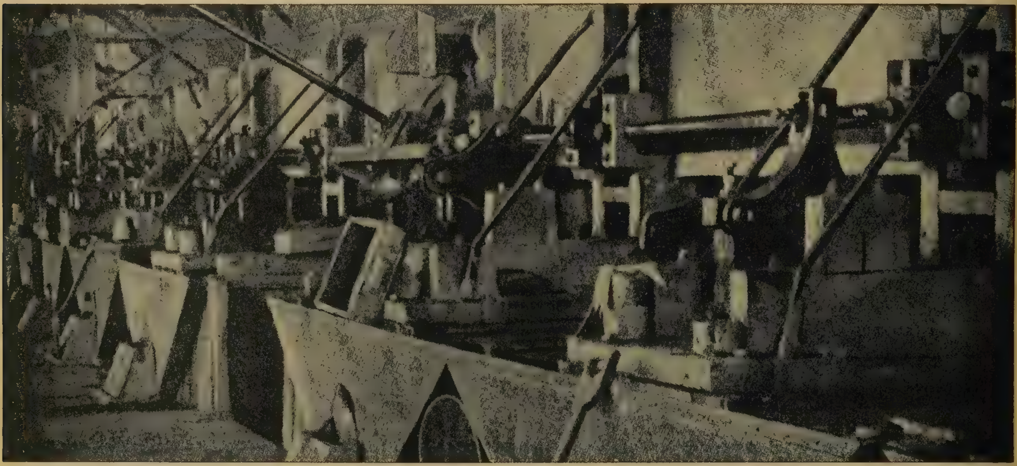
Nowadays artificial cold is applied to the waste liquor, and the chemicals are extracted from it at once. It is reckoned that 250 acres of salterns in a warm, southern climate will produce ten thousand tons of sea salt. But a spell of bad weather between March and September, when the evaporation is being carried on, sadly interferes with the production. For the process so entirely depends on the sun and the moon that in a wet season scarcely any salt is formed.


COLLECTING THE PILES OF SALT FROM THE EVAPORATION-PANS AT BENGHAZI, TRIPOLI

A DAY'S PRODUCE IN A DIAMOND MINE



WASHING-PANS IN WHICH THE SOFT EARTH IS REMOVED FROM THE MINERALS AND DIAMONDS



PULSATOR TABLES ON WHICH THE DIAMONDS ARE FURTHER SEPARATED OUT

A HEAP OF DIAMONDS SECURED IN ONE DAY'S WORKING

The "blue ground" is exposed to the action of the weather and harrowed by steam plows. It is then fed through perforated cylinders into the washing-pans or shallow cylindrical troughs in which the diamonds and other heavy minerals are swept to the rim by revolving toothed arms, while the lighter stuff escapes. The heavy minerals then pass over sloping tables known as "pulsators," where they are shaken to and fro under a stream of water, which effects a second concentration.

SEARCHING FOR THE MINER'S DEADLY FOE

These miners are searching for the deadly fire-damp. This gas, which causes so many explosions, is lighter than air, and rises to the roof of the mine. When a safety lamp is held in it, the flame burns blue, and the miner can detect it and take precautions. It escapes from the coal, often with a hissing sound, when the workings tap the cavities in which it is held.

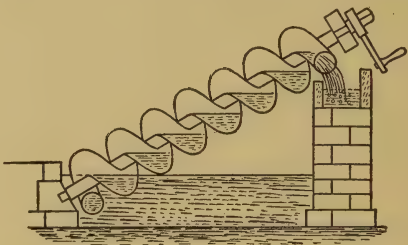
INVENTORS

ARCHIMEDES

A Great Scientist before the Time of Christ

ARCHIMEDES was born 287 B.C. at Syracuse, Sicily, then one of the chief cities of the Grecian world. The son of a geometer, and on terms of intimacy with Hiero, king of Syracuse, and with Gelo his son, he was educated in part at the great school of Alexandria, and maintained a regular correspondence with the students of geometry of that city. Regarded as the most perfect type of scientific intellect that has ever appeared in the world, he appeals to the popular mind by his inventions, and to the scholar by his researches and discoveries in pure science. It was to science that he was wedded. He scorned the mighty mechanical inventions of which he was the creator, and at which all the world wondered. He invented to order. Had he been living today, we should have asked him for the long-sought storage battery for electricity, or for a perfectly stable airplane, and we probably should not have asked in vain. King Hiero ridiculed his recondite studies, and asked for something tangible. As Plutarch tells us, Archimedes regarded his inventions only as among the amusements of geometry. "Nor had he gone so far, but at the pressing instances of King Hiero, who entreated him to turn his art from abstracted notions to matters of sense, and to make his reasonings more intelligible to the generality of men, applying them to the uses of common life."

Archimedes responded to his sovereign's call. He invented pulleys and windlasses, the water-screw or screw-pump, that endless screw which we find in operation today in ten cent toys and five thousand dollar automobiles; he invented various hydraulic and compressed-air machines;



ARCHIMEDES' WATER-SCREW

and the burning mirror, as to which the story is not disproved that he destroyed part of the Roman fleet when it appeared before the walls of Syracuse. For the defense of the city against the army of Marcellus he created engines of war whose fame has ever since rung through the world, towering structures which suddenly rose above the battlements, to hurl stones or masses of lead against the assailants, which dropped beams endwise on their ships, or flung out hooks which, grappling the galleys, tilted them into the air, then let them fall slanting to the bottom of the sea.

Equally startling defensive measures met the attack on the land side, and the terrified Romans could but sit down and wait. They starved the city into surrender, but the operation took three years. Archimedes, having done his duty, and

MACHINES THAT TALK

Photographs that Sing and Speak and Play
Music when a Ray of Light Shines on Them

SPEECH REPRODUCED BY STEEL WIRE

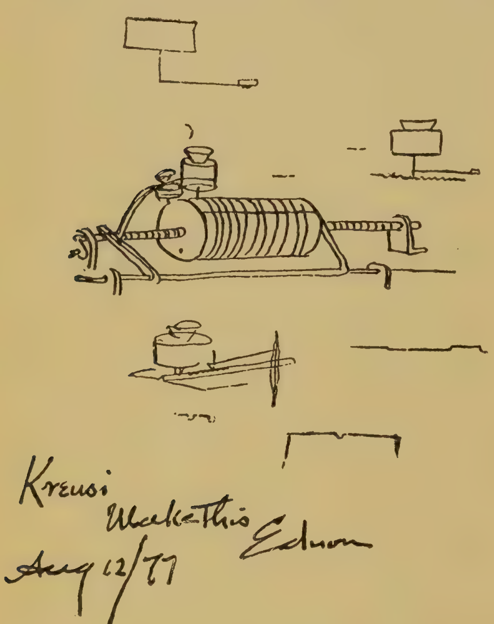
SOME years ago an American lad was anxious to become an expert telegraph operator. He was engaged at small pay in a telegraph office at Indianapolis in the daytime, but he was so keen to succeed that his day's work did not suffice. It was at night, when the line was being used for newspaper work, that speed in receiving messages was most necessary; and the lad figured that if he could get some of this night-work to do the practice would make him an expert, and enable him soon to earn bigger pay. The regular night operator was a man who often took more to drink than was good for him, and he was very glad when the boy offered to help him. So, while he was sleeping off the effects of his potations, the lad did his work for him. The ambitious youngster, however, was not by himself equal to the task, but he inspired another boy in the office with his desire to become an expert operator, and by working together they soon managed to get along fairly well. They each sat down for ten minutes at the instrument, and transcribed as much of the report as they could, and carried the rest in their memory. While one was writing out, the other was taking down.

This plan worked sufficiently well until a new man was put on at the Cincinnati end of the line. Now he was one of the quickest despatchers in this country, and the two lads found that it was hopeless to attempt to keep up with him. Yet the boy who had first resolved to become an expert operator did not mean to lose his chance of success without a struggle. His name was Thomas Alva Edison and the difficulty into which he had got himself spurred him on to devise the first of his inventions. Necessity was certainly the mother of it.

He obtained two old Morse registers, and made out of them a kind of tape machine. A strip of paper was run through the first receiving instrument, and as fast as the dots and dashes came from the Cincinnati despatcher they were printed in indentations on the paper. The paper was then run through the second instrument at the slow speed at which the two lads were able to work. So the messages would come in on one instrument at the rate of forty words a minute, and the two boys would grind them out of the other register at the easy speed of twenty-five. Mighty proud were the youngsters of their achievement. Their copy became so clean and beautiful that they hung it up on exhibition. The manager of the office used to come and gaze at it silently with a puzzled expression. His two infant prodigies, it seemed, were more than a match for the swiftest despatcher in the United States. He could not understand it; neither could any of the other operators. For the lads used to drag off their automatic recorder and hide it when their work was done.

But one night they could not keep up with their task. A presidential election was in progress, and copy kept pouring in at the top rate of speed, and the young operators fell two hours behind with their work of transcription. The newspapers sent in frantic complaints, an investigation was made, and Edison's little secret was discovered. He was not allowed to use his automatic recorder any more.

But he kept his machine for converting telegraph clicks into printed marks and changing these marks again into sounds. He went on improving the instrument, and by 1877 it was fairly perfect. It had an electromagnet connected with an embossing point, and when connected with a telegraph circuit the point would vibrate and indent the dots and dashes on a revolving disc of paper. The instrument would repeat the messages at any rate of speed desired. One day, as Edison was experimenting with the instrument and trying it at various rates of speed he noticed



FACSIMILE OF EDISON'S SKETCH FOR THE MODEL OF THE FIRST PHONOGRAPH

that one of the indented discs of paper, if revolved at a high rate, would emit a musical note. At that time he was also experimenting on the telephone and working out improvements on Alexander Graham Bell's ideas — his mind was filled with theories of sound vibrations, and their transmission by drum-like membranes. On hearing the musical note given out by the revolving disc an idea struck him that there was a possibility of recording and reproducing the vibrations of air caused by the human voice and other sounds. Hastily rigging up a crudely improvised instrument, he pulled through it a strip of paraffine coated paper and shouted against it, "Whoo-oo-oo." He then pulled the paper through again, and listened breathlessly. A faint, though distinct, sound was heard, but that was sufficient for Edison, who made this entry on his laboratory note book on that day, July 18, 1877:

"Just tried experiment with diaphragm having an embossing point and held against paraffine paper moving rapidly. The speaking vibrations are indented nicely, and there's no doubt that I shall be able to store up and reproduce automatically at any future time the human voice perfectly."

One of his workmen, Charles Batchelor, was very skeptical and offered to bet him a box of cigars that he couldn't make the thing go. Edison took the bet and kept on revolving the thing in his mind as to the best method of putting his ideas to a practical test.

On August 12, 1877, he made a rough drawing and wrote on it, "Kreusi, make this." He handed this sketch to one of his workmen, the late John Kreusi, saying, "Here's an eighteen dollar job for you." Kreusi, who was accustomed to this sort of procedure, looked at the drawing and said, "What are you going to do with this?" To which Edison replied that it was intended to be a machine that would record and reproduce speech. Kreusi said, "You're crazy this time," but he set to work and made the model from the drawing and in a few days brought it to Edison and stood by with a grin on his face. With much deliberation Edison fixed a sheet of tinfoil around the cylinder, adjusted the metal point and through the funnel shouted the words:

> "Mary had a little lamb,
> Its fleece was white as snow," etc.

He then adjusted the reproducing diaphragm, and on turning the cylinder again the words came back — a little squeaky but quite plain. Edison was astounded, for he had not expected such perfect results upon the first trial for the first model. Kreusi turned pale and said, "Mein Gott in Himmel!" Thus the phonograph came into existence — and Batchelor lost his bet.

THOMAS ALVA EDISON*
The Greatest Inventor of All Time

THOMAS ALVA EDISON was born at Milan, Ohio, on February 11, 1847. His father came of Dutch stock, the ancestral Edisons in America having been descendants of millers on the Zuyder Zee, who emigrated to this country about 1730 and settled in New Jersey. The family seems to have enjoyed a remarkable degree of longevity, for Edison's father lived to the age of 94, while his grandfather and great-grandfather lived until they attained 102 and 104 years of age, respectively. On the maternal side, Edison is of Scotch descent, his mother before her marriage having been Miss Nancy Elliott, daughter of Rev. John Elliott, a Baptist minister of an old Scotch family.

As a child Edison was rather fragile in appearance and was considered as being somewhat delicate. He was inclined to be very quiet and thoughtful, but exceedingly inquisitive, and asked so many questions as to tire out his parents and friends. Even as a child of five or six years old he showed a tendency to much originality of thought and an inclination to take interest in matters of a mechanical nature. On account of the assumed delicacy of his health, he was not sent to school at as early an age as usual, and even then he attended only a short time. His teacher reported to the inspector that the boy was "addled", whereupon Mrs. Edison indignantly removed him from school and undertook to educate him herself, she having formerly been a teacher in the high school. Under his mother's teaching and influence young Edison made good progress, and besides receiving a sound education was inspired with a taste for good reading.

At about 10 or 11 years of age Edison became greatly interested in chemistry, and having procured some books on the subject, persuaded his mother to allow him a space in her cellar for a laboratory. Here he experimented with such chemicals as he could procure at the local drug stores with his limited pocket money. He had gathered together about 200 bottles of various sizes and shapes to contain his chemicals, and labeled them all with the word "Poison", so that they would not be disturbed. At that early age, as later, he doubted the statements in books until he had proved them by experiment.

Edison continued his chemical studies at home until he was between twelve and thirteen years old, and then, finding that his pocket money was inadequate to purchase all the apparatus and chemicals he wanted, persuaded his father and mother to allow him to become a railroad newsboy, in order that he might earn money for his experiments. He received the necessary permission and thus came to sell newspapers, magazines, candy, etc., on one of the trains of the Grand Trunk Railway running between Port Huron and Detroit. Part of a baggage car was allowed him for his stock of goods, and into this space he moved his laboratory from home on to the train and there continued to experiment, but on an enlarged scale. He also bought a printing press and some type and published on the train a weekly newspaper which he called the *Weekly Herald*, of which he was proprietor, publisher, editor, compositor, pressman and distributor. The paper contained local, market and railway news, and had as many as 400 paid subscribers at one time. So far as is known, this was the first newspaper ever printed on a moving train, and by the youngest known editor in the world.


THE BIRTHPLACE OF THOMAS EDISON

Edison continued along these lines of work between two and three years until one day a bottle containing phosphorus fell off a shelf and broke upon the floor. The phosphorus set fire to the car, and the conductor put the boy and his belongings off the train and boxed his ears so soundly as to cause the beginning of the deafness with which he has always since been afflicted.

Some little time before this Edison had saved from death the child of a station agent along the line of the railway, and the father, in gratitude, offered to teach the boy telegraphy. This offer was eagerly accepted, and since that time Edison had assiduously studied the art, besides continuing his chemical and other studies. His career as a train newsboy being ended after the incident above related, he now obtained employment as telegraph operator, and at about 15 years of age entered upon this phase of his life.

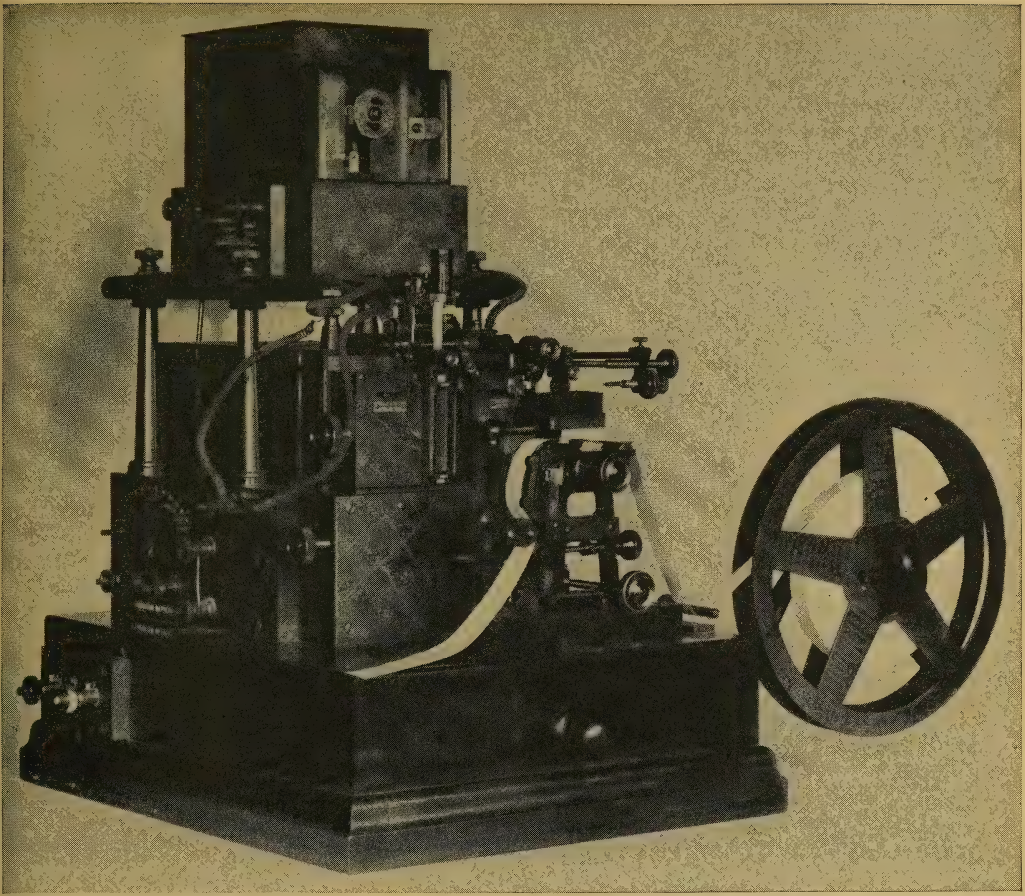
He plunged into the new occupation with great enthusiasm, and worked as an operator in telegraph offices in different parts of the United States. Having the ability of living with but a very few hours of sleep, he worked nearly twenty hours per day, and not only continued his chemical studies but also applied himself very closely to the study of electricity and the art of telegraphy. He was always willing to take the place of a skilled press operator and work through the night after working all day, in order to perfect his speed, and succeeded so well that he became one of the most rapid and efficient telegraphers of his day, and advanced to the position and pay of a first-class operator.

After a little more than five years of this kind of life, during which time he was constantly studying and devising minor improvements, he invented a duplex system of telegraphy which he tried to sell, but, through inefficiency and lack of honesty in his associates, he failed to consummate a sale. He also devised a stock-ticker in Boston in 1869 and put it into operation with a number of subscribers. Following some further adventures and work there, he determined to try his fortunes in New York City.

Edison arrived in New York one morning in 1869, and on leaving the boat was entirely without money, not having enough to buy a breakfast. In his extremity he walked the streets for part of the day, his only food being a little tea obtained from a tea-taster who was exercising his profession as Edison passed by. Later in the day he found a telegraph operator who lent him a dollar, with part of which more substantial food was purchased. Edison made application for work in the Western Union Telegraph Co., and got permission to sleep in a battery room of the Gold Indicator Co. until he could get a position.

While waiting for a favorable reply to his application, he spent his days in the operating room of the Gold Indicator Co. About the third day after his arrival there was an accident to the central transmitting machine, which stopped all operations on about 300 outside machines in customers' offices. Everything and everybody was in confusion instantly. Nobody knew what was the matter except Edison, who told the president of the company that he could fix it. He was told to do so, and in about an hour or two everything was operating satisfactorily. Edison was asked if he would accept a position as superintendent at three hundred dollars a month. This offer, which raised him from poverty to comparative affluence, dazed him for a moment, but he managed to stammer out that he would accept it.

This was the beginning of Edison's real inventive and commercial career. He stayed with the company for some time, made a great many improvements and inventions relating to stock printers, and finally received $40,000 for his inventions. Edison at this time was only 22, and this large sum, which placed him in a position of pecuniary independence, was the first money received from his inventions. This sudden affluence might have ruined an ordinary man, but not so with him. With this money he opened a factory in Newark, N. J., equipped it with first-class machinery and manufactured telegraph apparatus, employing over 150 men. He continued this business for several years, during which time he perfected several other important



Courtesy Western Union Telegraph Co.

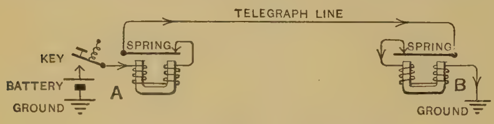
SIPHON RECORDER

This sensitive instrument records on a paper strip graphically by a wavy line the message sent over a long submarine cable. A wave to one side of the middle line represents a dot and to the other side a dash.

Talking through a wire

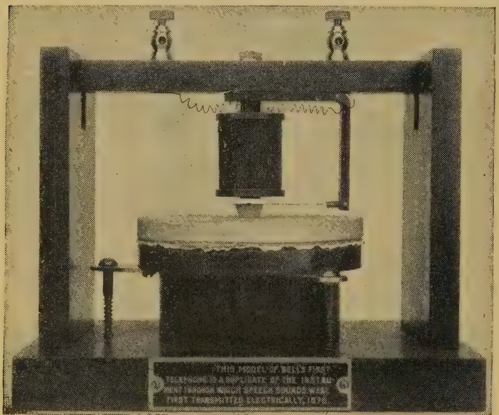
A few years after the introduction of the telegraph, it is reported that the operators amused themselves when business was slack by beating the time of the popular songs of the day with their telegraph keys. Many of the operators became so expert in this pastime that the song was easily recognized by the corresponding beats of the sounder at the other end of the line. In 1854 Charles Bourseul, in France, suggested that a diaphragm be connected to one of a pair of contacts in a telegraph line so that the vibrations of the diaphragm in opening and closing the circuit might produce pulsating currents in the line of the same frequency as the sound waves which fell upon the diaphragm. He furthermore explained that a similar diaphragm placed near an electromagnet at the other end of the line would vibrate by magnetic attraction and reproduce the original sound. No practical application of this idea was developed, but in 1861 Philipp Reis, in Germany, constructed an instrument which accomplished practically the same purpose. Reis called his instrument a "telephone" and succeeded in transmitting musical sounds with a fair degree of success, but his speech transmission for the most part proved to be imperfect. It will be seen from the later development that a minor alteration in the Reis telephone would have made it operate perfectly. In 1885 a monument was erected to the memory of the inventor in his native town of Gelnhausen.

In 1874 Alexander Graham Bell, a professor at Boston University, became interested in the study of multiplex telegraphy, a popular subject at the time because of the rapid development of the telegraph industry. He conceived the idea of sending several messages over a single wire by means of a number of pairs of steel springs. The following brief explanation of Bell's harmonic telegraph is given because it represents an important link in the development of the telephone.



BELL'S HARMONIC TELEGRAPH

When the key is closed at *A* the sending spring is attracted by the electromagnet, but in moving breaks the circuit so that the spring will vibrate continuously at its natural frequency while the key is closed.



Courtesy American Telephone and Telegraph Co.

MODEL OF PROF. BELL'S FIRST TELEPHONE

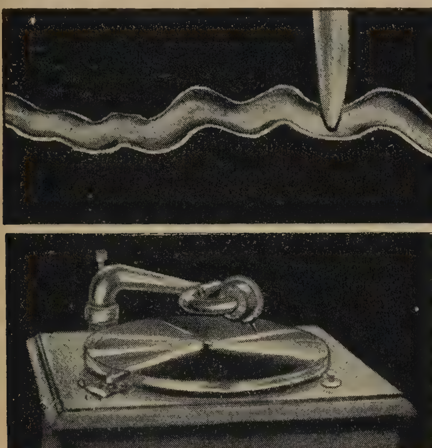
This is a duplicate of the instrument through which speech sounds were first transmitted electrically in 1875.

Since the current in the telegraph line pulsates at the same frequency as the vibrating spring, another spring at *B* at the other end of the line with the same frequency of vibration, will be attracted intermittently by the electromagnet. It is thus possible to make two similar springs vibrate in unison at the ends of a telegraph line. Bell believed that a number of these units could be connected to the ends of a single telegraph line and that several messages could be sent at the same time if each pair of springs was tuned to a different frequency of vibration. Although he built several models of this type of multiplex telegraph he was never able to make it work satisfactorily.

Bell's speaking telephone due to accidental discovery during telegraph experiments

During these trials he suggested to several friends the possibility of transmitting speech electrically, and it is evident that he was familiar with the attempts made by Reis in that connection. He was advised to persevere in the development of his harmonic telegraph, however, and the speaking telephone invented by Bell owes its existence in part to an accidental discovery made during these telegraph experiments. His mechanician, Thomas A. Watson, states that he was engaged on June 2, 1875, in vibrating one of the springs at the sending end of a short line in an attic on Court Street in Boston while Professor Bell was tuning a spring in another room at the other end of the line. The vibrating contact at the sending end accidently became welded together by the heat of the spark, and Watson in trying to break the fused contact plucked the spring several times. Professor Bell rushed in from the next room and cried, "What did you do then?" Bell had heard the exact sound of the sending spring reproduced by the spring at the receiving end of the line. It took him but a moment to realize that the vibrations of a spring placed near an electromagnet connected in a closed circuit will cause the current in the circuit to vary in strength at the same frequency as the vibrations of the spring. Since Professor Bell, like his father before him, was an expert in the science of sound and had devoted many years to the problem of teaching the deaf and dumb to speak, he quickly saw the possibility of replacing the spring by a diaphragm large enough to vibrate in accordance with the varying air pressure produced by the voice. After much experimentation with various shapes of diaphragm, a transmitter and a receiver were made which transmitted speech fairly well.

is 1-32,500,000th of an inch. Our eyes, however, cannot perceive a wave of light longer than 1-32,600th of an inch, or shorter than 1-62,850th of an inch. Our sense of light is the chief and most highly developed of our senses; it is the main avenue of knowledge to our intellect, yet it is terribly defective.



IMMORTALIZING THE HUMAN VOICE

The top picture shows a gramophone needle, much magnified, traveling in the grooves made by vibrations of air produced by the human voice. It follows the lines on the revolving disc, creating sound-waves exactly similar, and thus reproducing the voice.

But, after all, the mind of man is at last able to fashion instruments by which it can penetrate into the invisible worlds around it. By means of the microscope new forms of infinitesimal life are now being constantly discovered. The first microbe was seen by a Dutchman, A. van Leeuwenhoek, in the seventeenth century, but not until Pasteur's time was the study of the minutest of organisms conducted in a scientific manner. Strange as it may seem, the microscope is not, in spite of its wonderful power, the chief instrument in the discovery and study of the disease-producing microbe.

The armies of death which no microscope can reveal

Many of these invisible armies of death cannot be seen under the most perfect of modern microscopes. The limits of visibility with the microscope have been very carefully measured, and they are found to range from a hundred-thousandth to about two hundred-thousandths of an inch.

As under this magnification the outline grows very dim, many comparatively visible objects cannot be distinguished. In these circumstances, it is necessary to invent some color which will stain the microbe with a color different from the hue of its surroundings. This could not be done until the dyes made from coal-tar were carefully examined; and even at the present day there are many disease-producing microbes which are well known from their effects, but which cannot be stained and made visible. Some of them are fairly large, for they do not get through a filter; yet, until some means of staining them is discovered, they cannot be studied with a view to protecting mankind from their attack.

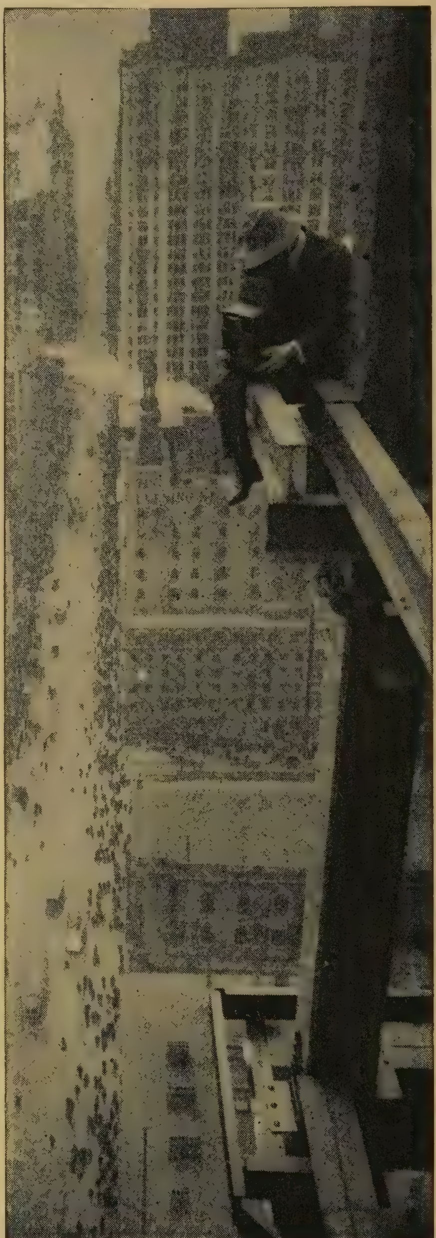
In regard to its extraordinary, fine power of measurement, the interferometer is far more important than the best microscope. By means of the interferometer an observer is able to detect a movement through one-five-millionth of an inch! The principle on which Professor Michelson of the University of Chicago constructed this instrument is very simple. The machine uses the minute lengths of waves of light. If two pebbles are dropped in a pond, say a yard apart, two systems of waves ripple out in circles. When the waves from the two systems meet, a varying effect is produced. If the crests of one set of ripples coincide with the

THE LITTLE INSTRUMENT WHICH MADE WIRELESS TELEGRAPHY POSSIBLE

We send a radio message by means of faint rays in the ether — so faint that at one time science knew no means of "picking them up." Then the "coherer" was invented, the instrument here shown, a tiny glass tube, in which are two silver plugs. Between the plugs is a space where lie loose grains of nickel and silver. It is these filings which "pick up" the waves and cohere, so completing a circuit and making the transmission of radio messages possible. Much more sensitive detectors have since been devised.

In 1878 George Eastman, a clerk in a Rochester (N. Y.) savings bank, learned how to make photographs from a local photographer at a cost of $5 for the lessons; but he was not enthusiastic over the load that had to be carried, nor the labor and pains involved. He chanced, however, to read an article in an English magazine on the possibilities of replacing the wet plate with a gelatine dry plate, and he experimented in his spare time and eventually discovered a coat of gelatine and silver bromide that had all the necessary photographic qualities. His achievement was contemporary with that of the commercial production of dry plates in England.

Although the wet plate was scrapped, so far as the amateur photographer was concerned, by the invention of the dry-plate process, it was in no sense superseded for certain technical purposes. It is used in photo-engraving and photo-lithography almost exclusively today. The dry plate, however, made it possible for the enthusiastic amateur to arm himself with the material for a dozen or more exposures in a very compact set of plate holders, and await his return to his dark room before development was necessary. But even the great strides made possible by the use of the dry plate did not really bring photography within the reach of the amateur, on account of the bulk and weight of the plates to be carried. Professional photographers remained by far the largest users of the new dry plate, and the real solution of the amateur photographer's problem pointed to a flexible, light, unbreakable base which should carry the sensitive silver emulsion.



PRESS PHOTOGRAPHY FROM THE DIZZY HEIGHT OF A CITY SKY-SCRAPER

Research on the part of Mr. Eastman and William H. Walker led to the manufacture of rolled film of coated paper to which the sensitized emulsion had been applied. This paper film, however, had the serious disadvantage that, even though it was greased to make it more transparent, the grain of the paper showed when the print was made. Its use, however, led to the appearance of the first Kodak in 1888.

A simple box camera was loaded with a roll of this paper film, sufficient for a hundred circular pictures, two and a half inches in diameter, and the wagon load of wet-plate paraphernalia was condensed into a little box which the photographer could tuck under his arm. After the hundred exposures were made, however, it was necessary to return the camera to the manufacturers for development and reloading; and in due course it was returned to him loaded for another hundred shots, and with the finished prints from his exposed roll.

The paper film was still unsatisfactory, however, and this led to a search for a transparent flexible film base which could be used for carrying the sensitized emul-

COUNTRY ROAD IN SPRINGTIME AS IT APPEARS ON A PHOTOGRAPHIC PLATE PREPARED BY THE LUMIÈRE PROCESS

RADIO COMMUNICATION

How Oscillating Electrons Produce Vibrations in the Ether that Fills All Space

THE WIRELESS TELEGRAPH AND TELEPHONE

WHEN James Clerk Maxwell, a distinguished English mathematician, suggested in 1864 that the light which we receive from the sun was transmitted through the intervening 93,000,000 miles of space by rapid vibrations in the ether, he also predicted the probable existence of slower ether vibrations which would produce no effect on the eye. Many scientists thereafter attempted to prove their existence. The first convincing proof of their presence was established in 1886 by Dr. Heinrich Hertz, a young German professor. The honor for the discovery of the transmission of energy through the ether may then be shared by Maxwell who predicted it and Hertz who produced and detected the vibrations.

Hertz produced the vibrations electrically by discharging a condenser through a short air-gap attached to the terminals of the condenser. The ether vibrations were detected by the spark produced in a short air-gap in a single loop of wire located at some distance from the condenser. He thus demonstrated that an electric spark at one place will produce an electric current in a wire at another place. He attributed the distant effect of the spark to ether vibrations which carried some of the energy of the discharging condenser to the loop of wire. Hertz also demonstrated that these ether vibrations could be reflected in the same manner that light is reflected from a mirror but differed from the light vibrations in that they would pass through substances which do not transmit light.

Sir Oliver Lodge, then a professor at the University of Liverpool, and Professor Righi of the University of Bologna, gave considerable attention to the discovery of Hertz and made many investigations of the properties of ether vibrations. In 1889 Professor Edouard Branly, a French physicist, made the important discovery that a small mass of metal filings placed

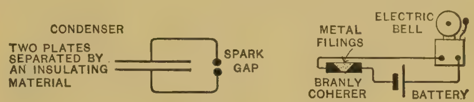


DIAGRAM ILLUSTRATING USE OF BRANLY COHERER

in a glass tube would become more compact under the influence of ether vibrations. With the Branly coherer it was then possible to ring a bell at a distant point by discharging a condenser through a spark-gap, as shown in the figure. When the terminals of the charged condenser are brought near enough together to produce a spark in the gap the ether vibrations cause the loosely packed metal filings in the coherer to become compact enough to complete the connection between the battery and the bell.

The experiments of Hertz, Lodge and Righi were directed toward a better understanding of the properties of the ether vibrations, and none of these scientists attempted at first to develop any kind of signaling device. The work of Hertz was brought to an abrupt end by his premature death in 1894. Guglielmo Marconi, a young Italian, became interested in the investigations of Righi and the other scientists, and in 1895 began to experiment for himself with the effect of distant sparks upon coherers. Marconi very quickly discovered that the ether vibrations would influence the coherer at a greater distance if one side of the spark-gap and the coherer

was connected to ground and the other side of each was connected to a vertical wire. By connecting one winding of an induction coil to two metal spheres — as Lodge had done previously — he was able to operate a telegraph sounder several hundred feet away by closing the battery circuit of the induction coil as shown in the figure. Marconi also kept the filings in the coherer in vibration by means of an electrically driven tapper so that after being compacted the filings would be loosened again and respond to the next signal.

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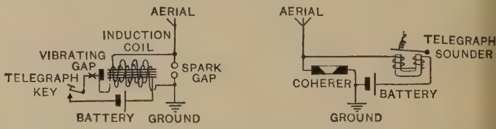
GUGLIELMO MARCONI

The first inventor of a successful radio telegraph.

At this time many other scientists became engaged in the development of wireless telegraphy. Experiments were conducted in England by Sir Oliver Lodge, Dr. Muirhead and Captain Jackson; in Russia by Count Popoff; in Germany by Professor Slaby; in France by Professor Branly; and in the United States by Nikola Tesla, Professor Fessenden and Dr. De Forest. Marconi made greater progress than the others, however, and in 1896 obtained his first wireless telegraph patent in England.

Under the patronage of the British government he began an extended series of experiments in which the distance of signaling was increased gradually from a few hundred feet to several miles. In 1899 he established wireless telegraph communication across the English Channel, a distance of thirty-two miles. In all of these experiments the equipment was essentially the same as that which he had first constructed. The greater distances were attained by producing stronger sparks and by erecting higher aërials.



MARCONI'S FIRST WIRELESS TELEGRAPH SENDING AND RECEIVING STATION

The Wireless Telegraph & Signal Company was organized in 1897 to develop the Marconi patents. The rights to the Lodge-Muirhead patents were purchased later and the name changed to Marconi's Wireless Telegraph Company. In 1900 Marconi was able to send wireless telegraph messages a distance of 200 miles and the next year he began the construction of two wireless telegraph stations for transatlantic service. One was located at Poldhu in Cornwall and the other at Wellfleet on Cape Cod. Both their aërials were blown down shortly after they were erected, but Marconi arranged to have the Poldhu aërial reconstructed, and started for St. Johns, Newfoundland, where he proposed to erect a temporary kite aërial. On the 12th of December, 1901, Marconi at St. Johns heard the repetition of three dots, the code signal for the letter "S," which came to him from the Poldhu station. He immediately began the construction of another wireless station at Cape Breton, Nova Scotia, and in a short time commercial messages were sent regularly across the Atlantic. Another wireless station was constructed at Clifden, Ireland, to take care of the increasing volume of traffic. Although the Wellfleet station was eventually placed in commission it has since been superseded by more powerful stations at Marion and Chatham.

PICTURE TRANSMISSION BY WIRE

A Development that Opens a New
Field for Printing News Pictures

A RECENT ELECTRICAL ENGINEERING MARVEL

ON May 19, 1924, exactly forty-four minutes after a picture was taken in Cleveland, Ohio, it was exhibited, completely developed, to a group gathered in a room of the American Telephone and Telegraph Company Building, New York, who had watched that picture being spun, flash by flash, upon the sensitive film of a complex machine.

Perfect in every detail, the photograph had been transmitted over long-distance telephone lines by a new system which is startling in its possibilities. Only five minutes were consumed in actual transmission of the picture, the rest being required for development purposes. The system is a development of the engineers of the American Telephone and Telegraph Company and the Western Electric Company, and it is the outcome of work covering several years. The apparatus in its present form represents the association of many recent inventions together with standard types of telephone and telegraph apparatus readapted to this new use.

The simplicity of the method is such that a positive transparency film supplied by any photographer is suitable for transmission. The apparatus is so designed as to transmit a picture five by seven inches in a little less than five minutes. The picture is received in such form that after photographic development of the usual sort, it is ready for newspaper or other reproduction. Line drawings, printings and handwriting can also be transmitted. As films can be used for transmission while still wet, this system eliminates the delay which would otherwise be caused by drying.

The process is as follows:

At the sending end there is a cylinder on which is wrapped a photographic film carrying a developed picture. On this is focused a beam of light which brilliantly illuminates an area one-hundredth of an inch square. This beam of light passes through the film and falls on a photo-electric cell which is mounted inside the cylinder. This device possesses the unique property of controlling the amount of electric current which can flow between the electrodes, in accordance with the amount of light reaching the interior of the bulb.

The electric current flowing through the photo-electric cell is amplified by vacuum tubes and is made to control the amount of current supplied to the telephone line. This current is transmitted over the line in the same manner as are the currents which carry the human voice in everyday telephone conversation.

At the receiving end of the telephone line this current is still further amplified and is made to operate a piece of apparatus known as a "light valve". The passage of the current received from the telephone line operates a little aperture, thus controlling the amount of light which passes through it. This light is brought to a focus on a cylinder corresponding to the one at the sending end of the line. The cylinder has wrapped upon it an unexposed photographic film, ready to receive the counterpart of the picture at the sending end.

By means of a special synchronizing system the cylinders at either end of the line are made to rotate at exactly the same speed, and by a screw mechanism the film is caused to advance parallel to the axis of the cylinder. The motion of the light

SOLDIERS' MONUMENT AND PUBLIC SQUARE

HIGH LEVEL BRIDGE

The above pictures were transmitted from Cleveland to New York over long-distance telephone wires in five minutes. On December 1, 1924, pictures of President Coolidge, the Prince of Wales and others were sent by a combination of telephone wires and radio waves across the Atlantic from London to New York.

THE SPLENDID SPIRIT OF THE GOOD OLD SAILING DAYS

BRISK WINDS — FROM THE PAINTING BY P. J. HARTLEFF

FACING PAGE 2400

Commerce

THIS section of the work, by Professor Allyn A. Young of Harvard University, tells the story of man's buying and selling—often things we never touch from and to men we never see, for money that never actually changes hands. It explains the intricate operations of modern finance the world around. It is a subject every business man must understand and has never been more completely or clearly elucidated.

The Creator of Wealth

How the world goes to market

In the advance of civilization the trader leads the way

The four conditions on which the trade of nations rests

The World's Real Wealth

Using up the energy of the future

The fuel that determines industrial leadership

Why our increasing population faces ever a rising cost of living

The Three Great Powers

The foundations of industrial supremacy

The tremendous share of the world's commerce controlled by the United States, Great Britain and Germany

The Industrial Future

How coal may transform the world

A survey of the lesser nations and the resources of the powers which will determine their position

America's Natural Endowment

Wealth, the collaboration of nature and man

Why 30% of the people earn their living in an area only 5.6% of the whole country

Our Wealth in Minerals

Need of public regulation of consumption

The annual output of the mines and quarries of the United States compared with other countries.

Our Water and Forest Resources

The present and the future problem

The two requirements necessary for complete utilization of water-power.

The difficulties in enforcing silvicultural measures, however just

Our Wealth in Cereals

How the laboratory may save

Why the food cost of living is ever increasing; the outlook for the future

Economic Interdependence of Nations

Minerals and military preparedness

The ideal of national economic self-sufficiency and its limitations

Not shortage in food supply the real difficulty in time of war

Wheat in International Commerce

The distribution of minor cereals

How national differences in wealth and standards of living affect agriculture

The Reign of King Cotton

The methods of the cotton market

America's great staple and its place in international trade

A modern gin cleans as much cotton in a day as hand labor could in a year

The Trade in Cotton Goods

The world's most valuable textile

The growth of the world's use of cotton

Great Britain's curious climatic advantages in Lancashire

Wool: The World's Staple

The past and future of sheep-raising

The fruits of an industry that, like the star of empire, westward takes its way

The Shipping of the World

Great Britain's supremacy on the sea

Canada's and Australia's splendid showing in steamship tonnage

Contrasting conditions at the beginning and end of the nineteenth century

Evolution of the Atlantic liner from 176 to 915 feet in length and 180 to 66,000 h.p.

America's Merchant Marine

New national problems confronting us

The shipping revolution brought about by the Great War

Problems the Shipping Board will never solve

Shortened Trade Routes

The great gain by America

The effects of the Panama Canal from a commercial point of view

Artificial Waterways
Early American experiments
Lessons offered by Holland, France, Belgium and Germany

American Water Routes
Waterways versus railways
Present problems of canal and river transportation in the United States and Canada
Why break bulk at the seaboard?

Trade and the Road
The illimitable hopes of progress
How railways, the life of modern land commerce, have changed the face of civilization
The world's railways and their lengths

Wealth and Well-Being
The value of American accumulations
The true nature of wealth and its acid test
Not less but better and happier work the right ambition

The Annual Wealth Product
An achievement of statistical science
The income of the people and its distribution among them

Trade's Iron Scepter
Why the lead has passed to America
The important rôle in economic progress played by steel
Germany not so badly nor France so well off as might appear

Foreign Trade of the United States
The changing character of our exports
Position in the world's markets of goods made in the United States
Classes of goods imported by us and where they come from

The Trade of Canada
A record of truly amazing growth
What our energetic neighbors across the border are doing
The most populous, wealthiest and industrially advanced of the self-governing dominions

The Making of Wealth
The possibilities of expansion
Just what is a productive laborer in the ultimate analysis?
Moving to the place wanted as important as making the article

The Sources of Wealth
The problems of our savings
The necessary parts played by land, capital and labor in the production of wealth

Labor and Wealth
The machine and the man
The saving of labor the real road to the increase of wealth
The loss to the individual by changes beneficial to the community

The Rise of Coöperation
Society as a coöperative framework
Reconciliation of individual enterprise with coöperative effort
Disadvantages that accompany unlimited competition

Combination and Monopoly
Sound and unsound control of prices
The right of a nation to organize industry for itself
Mere size or mass of capital gives no permanent monopoly

The Meaning of Value
Paradoxes of value and price
The diminishing satisfaction to be obtained from great wealth
Loss of purchasing power of money hard on investor and wage earner

The Mystery of Money
The enormous edifice of credit
How modern methods of payment economize the use of money

Monetary System of the United States
The evolution of the gold standard
Our various forms of currency and how their gold parity is maintained

Mobilizing Banking Credits
Possibilities of the Federal Reserve
The drastic reform of the banking system of the United States
Effect of new system during the war and its success

Dear and Cheap Money
How the foreign exchanges operate
The Bank of England and the mechanism of the London money market

Insurance and Speculation
The good and evil the latter does
How economic risks are diminished by combination and organization
How every business man is a risk taker and therefore a speculator

Money and Prices
The business cycle an economic disease
How unstable prices work havoc to industry and injustice to individuals
Debt-paying value of money falls with falling and rises with rising prices

THE SOURCES OF WEALTH

The Necessary Parts Played by Land, Capital, and Labor in the Production of Wealth

THE PROBLEMS OF OUR SAVINGS

THE requisites of wealth-production are, broadly, land, capital and labor. More broadly still they might be defined as land and labor. It is convenient to describe by the term "land" every natural agent — that is to say, not only the soil of a given area, but every gift of nature utilized by man, whether on, in or under the land or sea. It is well to bear clearly in mind that labor is not, as is sometimes loosely said, the only source of wealth. Labor has to be exercised upon the world's natural resources; and those resources are so unevenly distributed as between one country and another, and as between one locality and another, that labor exerted at one place may be very ineffective in wealth-production as compared with labor exerted at another place. It may help clarity of definition if we express our meaning, in other words, by defining "land" as that which owes nothing to labor.

So far as the surface of the earth is concerned, great parts of it have been worked over in minute detail for long periods of time, in some cases for periods stretching back beyond the confines of human history. Year by year, an increasing part of the earth's surface is being brought within the scope of man's civilization. There is perhaps no more wonderful thought connected with an old and developed country like England, or France, or China, than the reflection that almost every acre of it has been in some way scraped, or pared, or cultivated, or mined, or drained, or built upon. Here and there one may find a small spot which has remained undisturbed for a generation or more, but even that has probably been subjected to cultivation or alteration at some not very remote period.

Land is the source of all our materials, and of all our food. To the agriculturist it is, of course, the prime material. To the industrial captain, it is a fixed base upon which to do certain work, and, in its broader sense, the source of raw materials. To everyone, whatever his calling, it means so much space upon which not only to work but to live. If we inquire what are the distinguishing attributes of land, we find it in the elements of area and location. A certain piece of land is a definite space of the world's surface, the position of which cannot be changed in relation to other pieces of land. We see that these properties are unalterable, and that they inherently attach to land. Whatever else man may do to land, he cannot affect these distinguishing properties. The fertility of land may be increased or decreased. The amount of work to be done upon a certain piece of land may be increased by erecting a building of many floors, multiplying the working space available in respect to it. A definite piece of land, again, may be mined, and minerals brought up for utilization from far below the surface. A swamp or lake may be drained, and what was water-surface converted into more useful land-surface. These and many other things can be done by way of changing the character of land and the use of land. Through them all, however, it will be seen upon consideration that the unalterable qualities of area, or extension, and of situation remain.

THE MAKING OF WEALTH

How Industry and Trade Have Always Been Checked by Misdirected Effort

THE POSSIBILITIES OF EXPANSION

THE essence of the production of material wealth is to form new combinations of the matter supplied by nature, and industry and commerce alike are concerned with a useful exercise of motion. On analysis we see that all manufacturing is the issue in the form of useful articles of work done by moving into new positions the materials which nature supplies. We cannot either create or destroy matter, but with increasing effectiveness we can create or destroy utilities. We do not create matter when we cut down a tall tree and turn its trunk into timber, but we do create a new utility — timber. We do not destroy matter if we burn the timber; the matter is indestructible, and all that we do is to reduce it to other forms — gases, smoke (unconsumed carbon) and mineral ash. The burning, however, has destroyed utility, although it has not destroyed matter.

It is not possible for man to waste matter, it is only possible for him to create or waste utilities by changing the form of matter.

But man is ever filled with a desire for new forms and kinds of goods. As his powers increase, and as his command of nature increases, he demands an ever increasing complexity of manufactured articles. His desires are without limit. He calls for houses of the most complicated description, for clothes and personal ornaments of constantly changing type and of great elaboration; he demands for the fuller enjoyment of his powers the constant use of an enormous range of utilities in the shape of prepared foods, furniture, utensils, books and papers, instruments of sport, musical instruments, vehicles, etc. The ever-growing facilities for the conduct of agriculture therefore serve to set free an increasing proportion of working people to devote themselves to manufacturing. The call for agricultural work has decreased, and must, relatively, decrease. The call for the products of industry is ever growing.

Well-ordered movements produce wealth, but labor consists of movements not always well ordered. Labor, then, is a source of wealth; but it would be a mistake to suppose that all labor produces wealth, for much of it is not well ordered.

When we say that labor is not well ordered, we mean that it is wasted, that is, that it is not exerted in such a way as to contribute directly or indirectly toward increasing the stock of utilities which consumers are demanding. It requires as much labor to sink a deep well in a region in which, for geological reasons, there is no possibility of finding oil as to sink as deep a well into rich oil-bearing strata. But in one case the labor is wasted, and in the other it is productive. Men confined to their homes by illness, or in prison by a court sentence, sometimes while away the tedium of their lives by carving absurdly intricate and fanciful articles of wood. Even though they may have cost years of labor, such articles generally have no value, except perhaps in unusual cases as curiosities. We should see clearly that it is *not labor that gives value to goods*. It is the value of the goods produced which gives value to labor. Labor does not create value; the value of labor is nothing but the reflected value of what labor produces.

LABOR AND WEALTH

How the Progressive Economy of Labor is the Only Means of Increasing the Supply of Commodities

THE MACHINE AND THE MAN

WE now come to the deeply interesting considerations which attach to the economy of labor. In the first place, we shall do well to remind ourselves that the primary object of trade and industry *is not to make but to save work.* The conception that the making of work, or the giving of employment, is an end in itself is one of the most hoary of economic fallacies. We must remember, however, that if it is still cherished it is because the saving of labor in an imperfect civilization is accompanied by loss and suffering to individuals. We must not, therefore, be tempted to regard it lightly, and to dismiss with hilarity the employer or workman whose circumstances cause him to entertain the delusion.

The fallacy we refer to is often uttered by those who excuse the most luxurious and wasteful expenditure on the grounds that it "makes work". No matter how wanton an extravagance, there are never wanting those ready to make excuses for it on the ground that it gives employment. If the making of work is the end of life, then it is obvious that, the more laborious trade and industry can be made, the better they are for mankind. Why plow, when it would obviously make more work to loosen the soil of a field by digging with a stick, or even by pulling its clods to pieces with the fingers? Why use a cart, not to mention a railway, when it is obvious that more work would be made by dragging loads over a road by manual labor? Why, indeed, make a road, when it is obvious that, if it did not exist, there would be much more work made in moving things about?

When a workman says that he is suffering from lack of work, what he really means is that he is suffering from lack of income, and work presents itself to him as the only means of obtaining the income. We must not wonder, therefore, if the necessity of finding work presents itself to him as the main object of life, and if he is but only too prone to entertain the economic fallacy to which we have referred. Indeed, it is not much use to the unemployed workman to remind him that one of the prime objects of civilization is to reduce the amount of work to be done to produce a given amount of comfort, or a given quantity of utilities.

The workman is only an insignificant part of an economic chain which he did not create and cannot control, and he is forced only to consider the immediate point, which is how to get a wage. We must not expect him to question the economic bearings of the means by which he earns his wage. The workman may be an exceptionally intelligent man, able to tell you that what most wants doing in his immediate neighborhood is, let us say, to rehouse people like himself in order to enable them to live decent lives. He may know that economic truth, but of what avail is the knowledge to him? He must find income by obtaining employment; and if, therefore, the work offered him is to assist to build up a luxury, and, in effect, to waste his work from a social point of view, he must needs accept the offer of employment, and he must needs regard the making of work — however foolish, however wasteful, and however absurd — as the immediately desirable thing.

THE MEANING OF VALUE

The Remarkable and All-Important
Interplay of Supply and Demand

PARADOXES OF VALUE AND PRICE

IN its economic sense "value" does not mean usefulness; indeed, things may even be useless for any good purpose and yet have economic value. To the economist, a thing possessing value must have value *in exchange.* A commodity which cannot command other commodities in exchange has no economic value. Thus the water of the ocean, which is so valuable in the ordinary sense that without it the world could not exist and navigation could not be conducted, has no economic value. Similarly, the atmosphere, without which all organisms would perish, although invaluable in the ordinary sense, has no economic or exchange value.

Using "value", then, in its economic sense, we see that it is a relative term. One commodity is exchangeable for varying quantities of other commodities at different times. At any one time it will exchange for more of this or less of that. A very large quantity of things easily secured will exchange for a very small quantity of things difficult to obtain. Broadly speaking, some kinds of commodities are in general produced easily, and large quantities of them, therefore, are needed if we desire to exchange them for other things which are difficult to procure or to manufacture. At different times the ratios vary considerably, however; in one year a much larger quantity of wheat may be required to purchase a piece of iron than in another year.

The conception of value as a *relative* term cannot be too clearly understood. At any given moment the value of one thing may be falling relatively to one commodity and rising relatively to another. Let us consider two consecutive years, 1921 and 1922. Let us suppose that in 1922 as compared with 1921 the supply of rubber is increasing more rapidly than the supply of wheat, while the supply of iron is decreasing. In such hypothetical conditions, wheat in 1922 is rising in value as compared with rubber, but falling in value as compared with iron. We should have, in 1922, to give less wheat than in 1921 to get a given quantity of rubber, and more wheat than in 1921 in order to get a given quantity of iron. Exchange value is thus purely a *relative* thing. Thus, in the case quoted, who can say whether the value of the wheat has risen or fallen? It has actually done both, according to whether we consider it in relation to rubber or in relation to iron.

What, then, do people mean when they talk about values falling at a certain time or rising at a certain time? The answer is that they do not quite know what they mean, and that they are suffering from a confusion of thought. It is important to see how this confusion of thought arises.

When all values become an expression of what we can exchange everything for in terms of money, we get the phenomenon of *price,* which is simply the *exchange ratio of the article we select as money to some other commodity at any given moment.* Now we see why people talk loosely of a fall in "values", when what they mean is a fall in "prices" — *i.e.*, an increased plentifulness of things in general in relation to the accepted monetary standards.

If we have a clear perception of "value" as a relative term, and of "price" simply as an expression of the relation of commodities in general to a particular commodity — money — at any particular moment, we are helped to think clearly upon many common

THE GLORY OF THE SEA IN EARLY DAYS

A SHIP OF THE DAYS OF DRAKE — IN SUCH A VESSEL THE FIRST VOYAGE ROUND THE WORLD WAS MADE

FACING PAGE 2160

INSURANCE AND SPECULATION

How Economic Risks are Diminished
by Combination and Organization

THE GOOD AND EVIL SPECULATION DOES

IN popular discussion insurance and speculation are often confused with gambling. As a matter of fact, as we shall see, the individual differences and peculiarities of these three forms of activity are much more striking than are their similarities and likenesses.

Insurance is really the direct opposite of gambling. The peculiar characteristic of gambling is that it always involves the *creation* or *unnecessary assumption of risk.* If I gamble by tossing a coin or by throwing dice, I assume a risk and incur a chance of loss as well as a chance of gain in a manner that is wholly arbitrary and unnecessary. The coin need not have been tossed had I not so willed, and even if it had been tossed, I need not have entangled my personal fortunes with the outcome of the throw. In a horse race it normally happens that one horse wins and that the others are defeated. But this need not affect my personal fortunes. There is absolutely no risk to me in the outcome of any horse race unless I create the risk by betting on it.

It is not our purpose here to discuss the morality of gambling. We are merely concerned with its economic characteristics. We have seen that it is unnecessary, that it involves the creation of risks. And gambling has a further economic disadvantage. In the long run and on the average it necessarily involves *a net social loss.* The utility of gambling gains cannot offset the real disutility of gambling losses. To make the point clear, imagine that A and B both have incomes of $1000 per year. They wager one against the other $500 on the outcome of a certain event. A wins; B loses. A's income for the year is now $1500, while B's is only $500. For reasons which we have already discussed and which are so obvious as scarcely to need explanation, there is more difference between incomes of $1000 and $500 than between incomes of $1000 and $1500. Measured in terms of utility, A's gain does not offset B's loss. Unless successful gamblers are in general poorer men than unsuccessful ones, unless, in other words, gambling involves on the whole a transfer of wealth from the rich to the poor — an absurdly impossible assumption — it follows that gambling is responsible for a net social loss of utility. Gambling is not merely non-productive; it *destroys* rather than creates utility. This conclusion gains increased significance when we take account of the further fact that gambling gains are very commonly spent in a wasteful and extravagant fashion. The real costs, the hazards undergone, are forgotten. The winnings of gambling, easily got, are easily spent.

In economic analysis we thus find a strong case against gambling. And we have purposely taken no account of the fact that gambling very often weakens the moral fiber of the individual, although that fact has economic importance. Gambling makes men less inclined to the sustained and systematic effort which the work of economic production requires.

How, then, does insurance differ from gambling? Is not a fire insurance contract a wager between the insurance company and the insured? Does not the one virtually wager that the insured property will not be damaged by fire within the year,

The causes of the rise and fall of the rates of exchange

Again, the mint par between the United States and England is 486.7 cents to the pound sterling. We hope we have made it clear that the mint par of exchange has sole relation to the amount of pure gold contained in the various coins. Obviously, as between a gold-standard country and a silver country, like China, there cannot be a mint par of exchange. Now let us suppose that as between two countries the claims for payment at a certain time are equal. That being so, exchange is at the theoretic par of exchange — *i.e.*, if the two countries were the United States and England the claims would be settled at the exchange rate of approximately the English sovereign, $4.87. But, of course, it rarely happens that there is such an equivalence of indebtedness between any two countries; and it will be seen that if on a certain date there is more to remit from the United States to England than from England to the United States, there will be a considerable demand in the United States for bills of exchange as a means of remittance to London. Consequently, the price of a bill of exchange would rise in New York, or, in other words, the rate of exchange would rise.

To express it in another way, a bill on London would be at a premium; an American importer desiring to remit would be willing to pay more than the mint par of exchange — *i.e.*, *more than 486.7 cents per sovereign for it.* There is, however, a practical limit to the premium he would be willing to pay. That limit is fixed by the cost of buying, shipping and insuring gold, and that limit is known as "the gold point". A moment's thought will show that this gold point strictly limits the premium of exchange, and is the point at which gold is paid instead of a bill of exchange, or promise to pay gold.

The insignificance of the commerce in gold compared with the bulk of trade

Now we see how it is that gold comes to be shipped in settlement of debts between one country and another. In relation to the enormous bulk of international transactions which take place, the shipments of gold are trifling. In point of actual size, however, the shipments of gold are great. For example, in the year 1914 the commerce in goods and gold of the United States was as follows:

SHIPMENT OF GOODS AND GOLD: 1914

Imports of Goods	$1,854,376,750
Exports of Goods , ...	2,500,120,669
Exports of Imported Goods . . .	37,377,791
Total Trade in Goods	$4,391,875,210
Bullion and Specie Imported . . .	$69,194,025
Bullion and Specie Exported . . .	77,762,622

It will be seen that while in a single year our imports and exports of merchandise amounted in value to the enormous sum of $4,392,000,000, our inward and outward shipments of bullion and specie amounted to less than $150,000,000. It it plain, therefore, that the great bulk of the necessary payments were made by the transmission of bills of exchange, and that the shipment of gold played only a comparatively small part. Nevertheless, when transactions in gold are compared with the gold reserve at the Bank of England and other central banks we get a very different effect of proportion. In relation to the total volume of trade the commerce in gold is insignificant; *in relation to the bank reserves the commerce in gold is considerable and significant.* We see that it is large enough and frequent enough to have a very appreciable effect on the money market.

The daily table of foreign exchanges a thermometer of trade balances

We can understand, then, how important are the tables of foreign exchanges which appear in the money columns of the daily newspapers, and how closely they are watched. The movement upward or downward of rates of exchange with any particular country shows in which direction the balance of indebtedness is tending. For example, here are the rates of exchange as they were given in the daily newspapers of January 31, 1924:

TYPES OF UNITED STATES GOLD COINS, 1840–1923

DOUBLE EAGLE, 1850–1907 — REVERSE, 1866–1907 — REVERSE, 1850–1865

DOUBLE EAGLE, 1907

DOUBLE EAGLE, 1907–1923

EAGLE 1838–1907 — REVERSE 1838–1865 — REVERSE, 1907–1908 — REVERSE, 1908–1923

REVERSE, 1866–1907 — EAGLE, 1907–1923 — REVERSE, 1907–1908 — REVERSE, 1908–1923

HALF EAGLE, 1839–1907 — REVERSE, 1839–1865 — REVERSE, 1866–1907 — HALF EAGLE, 1908–1923

THREE DOLLARS, 1854–1889 — QUARTER EAGLE, 1840–1907 — QUARTER EAGLE, 1908–1916

ONE DOLLAR, 1849–1854 — ONE DOLLAR, 1854–1856 — ONE DOLLAR, 1856–1889

SILVER COINS OF THE UNITED STATES, 1840–1923

STANDARD DOLLAR, 1840–1873

REVERSE, 1840–1865

REVERSE, 1866–1873

TRADE DOLLAR (demonetized), 1873–1885

STANDARD or "BLAND" DOLLAR, 1878–1921

PEACE DOLLAR, 1921–1923

HALF DOLLAR, 1839–1891

REVERSE, 1853 only

REVERSE, 1839–1865

REVERSE, 1866–1891

HALF DOLLAR, 1892–1916

HALF DOLLAR, 1917–1923

SILVER COINS OF THE UNITED STATES, 1840–1923

QUARTER DOLLAR, 1838–1865

QUARTER DOLLAR, 1853–1855 REVERSE, 1853 only

QUARTER DOLLAR, 1866–1891

QUARTER DOLLAR, 1892–1916

QUARTER DOLLAR, 1916–1923

REVERSE 1916–1917

REVERSE 1917–1923

DIME, 1838–1860

OBVERSE 1853–1855

DIME, 1860–1891

TWENTY CENTS 1875–1878

DIME, 1892–1916

DIME, 1916–1923

OBVERSE, 1873–1875

HALF DIME 1838–1859

OBVERSE 1853–1855

HALF DIME 1860–1873

THREE CENTS, 1851–1853

1854–1858 THREE CENTS

1859–1873

MINOR COINS OF THE UNITED STATES, 1840–1923

1866–1867 NICKEL FIVE CENTS 1867–1883

NICKEL THREE CENTS, 1865–1889

NICKEL FIVE CENTS, 1883–1912 1883 only–REVERSE–1883–1912

NICKEL FIVE CENTS 1913–1923

1913 only

REVERSE 1913–1923

COPPER-NICKEL CENT 1856–1858

COPPER-NICKEL CENT 1859

COPPER-NICKEL CENT 1860–1864

BRONZE CENT 1864–1909

BRONZE CENT 1909–1923

BRONZE TWO CENTS, 1864–1873

COPPER HALF CENT, 1840–1857

COPPER CENTS, 1840–1857

STRANGE COINS OF OUT-OF-THE-WAY LANDS

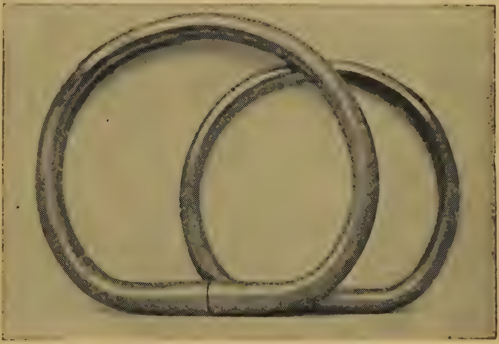
AFRICAN RING-MONEY

SHARK'S TEETH, NEW GUINEA

LARGE CHINESE "CASH"

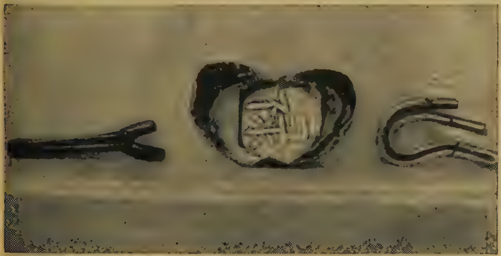
ANCIENT BRITISH SWORD OR IRON CURRENCY BARS, REFERRED TO IN CÆSAR'S COMMENTARIES

COCHIN CHINA SILVER WILLOW-LEAF

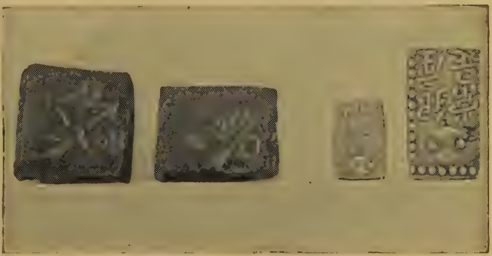


CHINESE SILVER BRACELET-MONEY

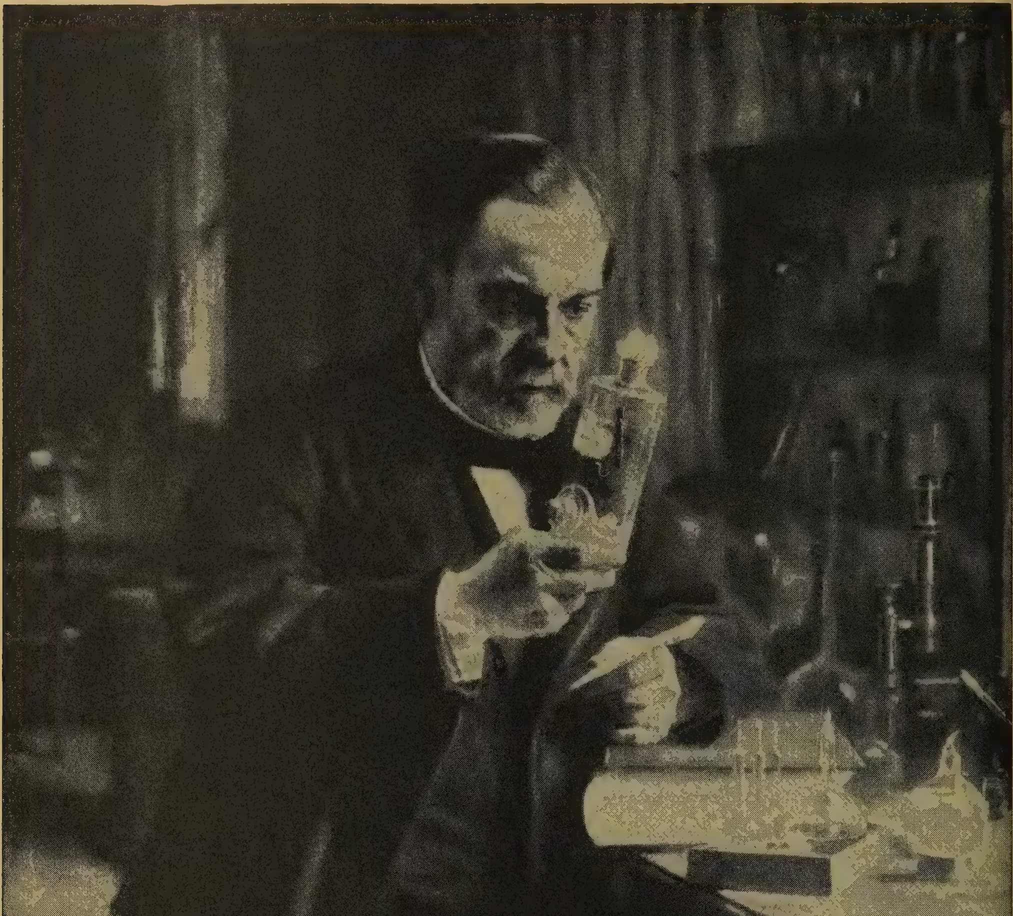
SIAMESE BULLET-MONEY, NOW OBSOLETE, THE LARGEST BEING WORTH FOUR TICALS, OR 4S. 8D.



LONGBIT OF HASSA, ARABIA, OF A.D. 920; CHINESE SILVER BOAT; AND CEYLON FISH-HOOK MONEY



SWEDISH KLIPPES OF A.D. 1611-1632, AND TWO JAPANESE SILVER "SQUARE" COINS OF A.D. 1772



The possibility of the production of life from not-living things was keenly debated by the scientists of the last generation, and Pasteur made up his mind against this possibility after a long series of experiments, which showed that, with all the known materials ready in the test-tubes, no life could be produced.

Man

HERE we come to the masterwork of the Master Mind, "not the lucky outcome of blind nature's endless play with ever-changing forms of life, not the offspring of brute forebears owning no other author or god than an 'ultimate biological necessity,' but the final creation of the Maker of the Universe to Whose likeness he was fashioned." What he is and what makes him so; his brain, and how it functions; his body and how it moves, erect, far-seeing, listening, sensing; the transmission of his characteristics to his offspring; his hopes of his soul's immortality; all this goes to make up an enthralling series of chapters.

The Supreme Organ of Life

A summary of evolutionary change

Design and structure of the brain and the known functions of its component parts
The skull's accommodation for the brain a rough measure of mental capacity

What Brain Study Shows

The switchboard that links up the mind

The astonishing foldings of the brain and the activities that are traced to each
The cells that feel sensations and those that initiate involuntary movements

Mind the Essence of Man

An introduction of psychology

Something vastly more than consciousness, to be studied in lowly ways, but linked with the Divine

The Beginnings of Mind

Consciousness that may be everywhere

Bridging the interval between simple sensation and conscious, creative thought
The essential organ of mind, which we call the brain, is only part of a greater whole

The Eye and Vision

How the brain sees, recalls and creates

Marvelous mechanical contrivances for the transmission of the materials of sight

The Wonders of the Ear

Do we think through sight or hearing?

The ingenious adjustments that permit the multitudinous and delicate uses of the ear

Man's Lesser Senses

The five gateways of sensation

Touch, smell and taste, and their seats in the skin, nose and tongue

Some of the Inner Senses

Miseries of internal origin

How the organic sense of well-being underlies all possible happiness

The Senses and the Soul

The need for the use of the word "soul"

The extension of the effects of physical stimulation into the region of psychology

The Origin of Thought

The putting of two and two together

Man's growth as a thinker through his superior brain-facility for the association of ideas
Motive power, not body, in men as in automobiles, what really counts

Memory and Attention

The art and secret of learning

How we retain interesting experiences, recollect them, and recognize them when they are recalled
Misdirected labor of trying to improve retention instead of association

Intelligence and Speech

The speech-center of the brain

How intelligence has grown with the growth of speech, and thought forms itself in speech

Instinct and Emotion

The modern study of psychology

Instincts—innate specific tendencies of the mind not acquired during the individual lifetime

The Elements of Emotion

The coming of fear, wonder and love

The association of instinct and emotion as seen in flight and fear
Parental instinct and mother love

Processes of the Mind

The how and why of our behavior

An examination of the operations of suggestion, imitation, habit and temperament
The psychology of the crowd and the contagious character of emotion

Will and Self-Control

The significance of self-respect

Teachings of science and experience on the question of the freedom of the will
Hypnotism only possible with the assent of the will

The Inmost Self of Man

Man's unique self-consciousness

The principle of unity in the measureless multiplicity of the body
The concept of a self the distinguishing characteristic of man

The Mystical World of Mind

Telepathy, hypnotism and spiritism

Queer things that lie beyond our senses and puzzle science and scientists

A Survey of Hypnotism

Strange effects of susceptibility

The different levels of the hypnotic state and how they can be used and abused
Part played by personality of the hypnotist

The Greatest Men of All

The clearer presence of God Most High

The study of genius and the foolish fallacy that it and insanity are closely allied
The highest hours of the highest minds man's rarest heritage

Our Personal Destiny

If a man die shall he live again?

Testimony of the human soul to our persistence and continued identity
An effective suggested parallelism between physics and psychics

THE MASTER OF THE EARTH

The Difference that makes the Difference in Man — How his Improvement in Mind and Hand made him Lord of Creation

THE MOST ASTONISHING THING IN NATURE

"What is man, that Thou art mindful of him? Thou hast made him a little lower than the angels, and hast crowned him with glory and honor. Thou madest him to have dominion over the works of Thy hands; Thou hast put all things under his feet: all sheep and oxen, yea, and the beasts of the field, the fowl of the air, and the fish of the sea, and whatsoever passeth through the paths of the seas."

WHAT is man? remains the question of questions now, as it has for ages been. The "lord of creation," on whose dead body the worms feast, the paragon and paradox of animals, asks what he is. But in our own time the question is nearer answering than ever before. The nineteenth century established staggering yet evident truths which not even the ignorant now challenge, and the twentieth may establish truths regarding man's mind no less notable.

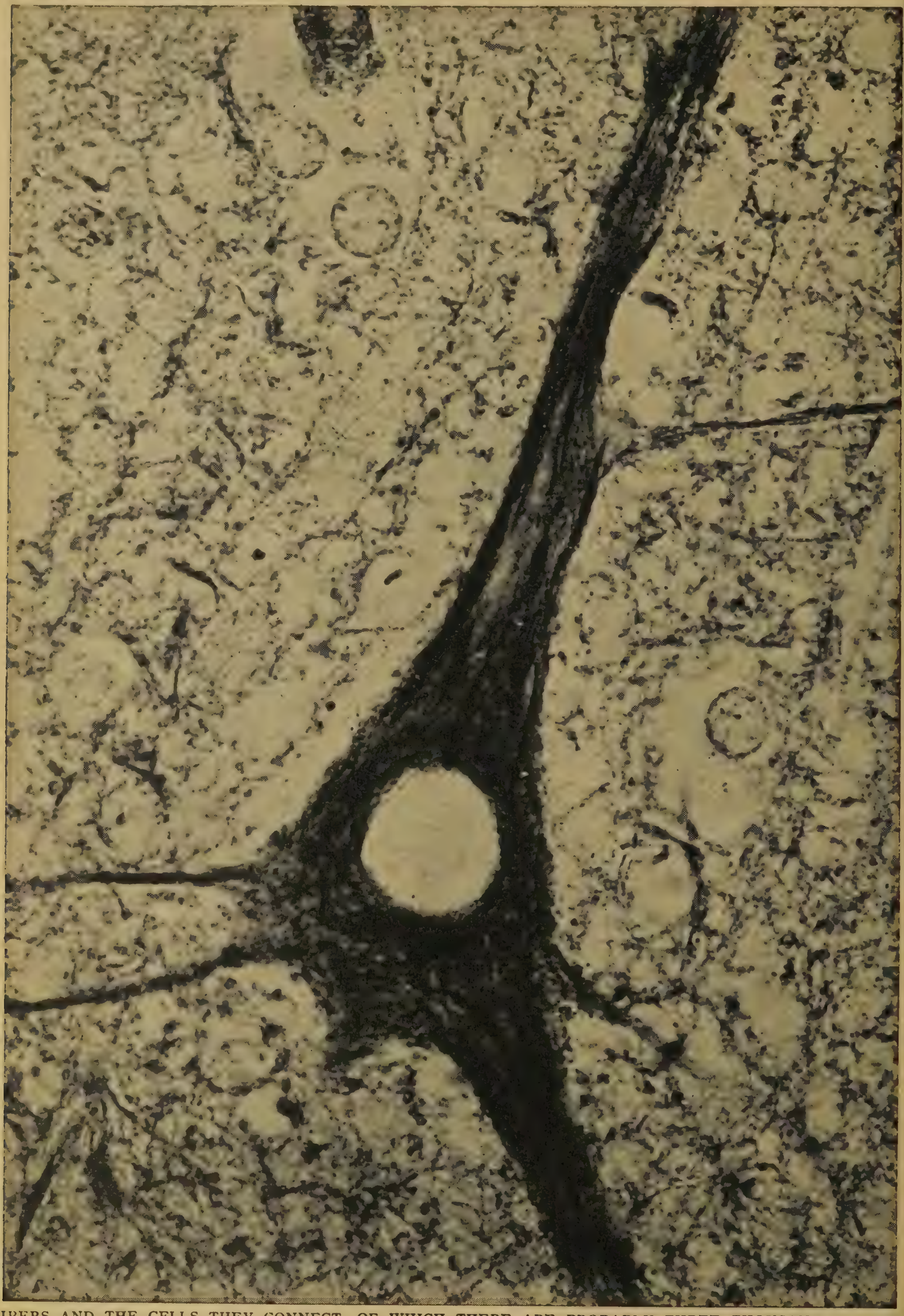
In this initial chapter of the study of man it is open to us to adopt either of the two tendencies which for half a century have divided the students of this subject. They are well defined, and there is no mistaking to which party almost any writer belongs. We may insist upon the numerous radical, profound, unchallengeable, all-significant resemblances between man and the lower animals, and may demonstrate beyond question that he is their relative in the sense that the fundamentals of his constitution are the same as theirs, that his body has the same needs and the same destiny, that his young pass through similar stages, and even that, at certain of these stages, they are actually indistinguishable from the young of many of the higher animals.

Meanwhile, we may slur over or minimize any differences as non-essential, superficial, or trivial. It is true that, by this method, we shall succeed in leaving man wholly unexplained as regards his record and his place in nature, but if our object is to show that he is only the most modern of the higher animals we shall be content.

On the other hand, we may prefer to insist upon the numerous radical, profound, unchallengeable, all-significant differences between man and the lower animals, and may readily convince ourselves, by this means, that he is unique, unprecedented, unrelated, incomparable, an exception to all laws. It is true that this method also has its serious disadvantages, since it leaves wholly unexplained the origin of man, not to mention half his attributes of mind and nearly all his attributes of body.

Science, however, so long as it is true to itself, must ignore or despise no order of facts. Its object is truth, of which all facts are part. If the body of man displays some hundreds of definite anatomical characters which it shares with the higher animals, science must reckon with this fact and its meaning. If the mind of man displays powers so far transcending the utmost displayed by any other form of living nature that we are almost entitled to call him supernatural, if his genius in a hundred directions is as unimaginably novel as his backbone or his muscles are archaic, science must reckon with this fact, too. If there is apparent contradiction, it must be faced, with the full assurance that it is only apparent.

A CENTER OF ACTION IN A MAN'S BRAIN



FIBERS AND THE CELLS THEY CONNECT, OF WHICH THERE ARE PROBABLY THREE THOUSAND MILLIONS fied 1650 times. A center of nerve impulses which control the "doing" of things, it is called a "psycho-motor" cell, because it is not merely motor but voluntary-motor, controlling the action of the muscles of the body. Most of the cells and fibers are, however, concerned in receiving impressions, elaborating them by association, and storing them up in the memory. We know that these cells are the anatomical basis of mind, because they are ill developed in imbeciles and wasted in those who have lost their mind.

PROCESSES OF THE MIND

An Examination of the Operations of Suggestion, Imitation, Habit and Temperament

THE HOW AND WHY OF OUR BEHAVIOR

IN our study of man we are steadily advancing towards true ideas of the why and the wherefore of his acts. We know, or ought to know, that nothing else really matters. We might therefore have begun our account of him by considering his will, his purposes, his character. If we have done otherwise, beginning with merely physical and physiological considerations, that is only because the history of thought teaches us the advisability of doing so. Many thinkers and students of man in the past have begun with his supreme and essential attributes, but we believe that they have often erred because they were not content to begin with the base degrees by which he did ascend. On the other hand, we may safely prefer their account of man to those provided by too many physiologists of today, who begin with the base degrees, and, being unable to get any further, end by denying that man, as he really is, exists at all.

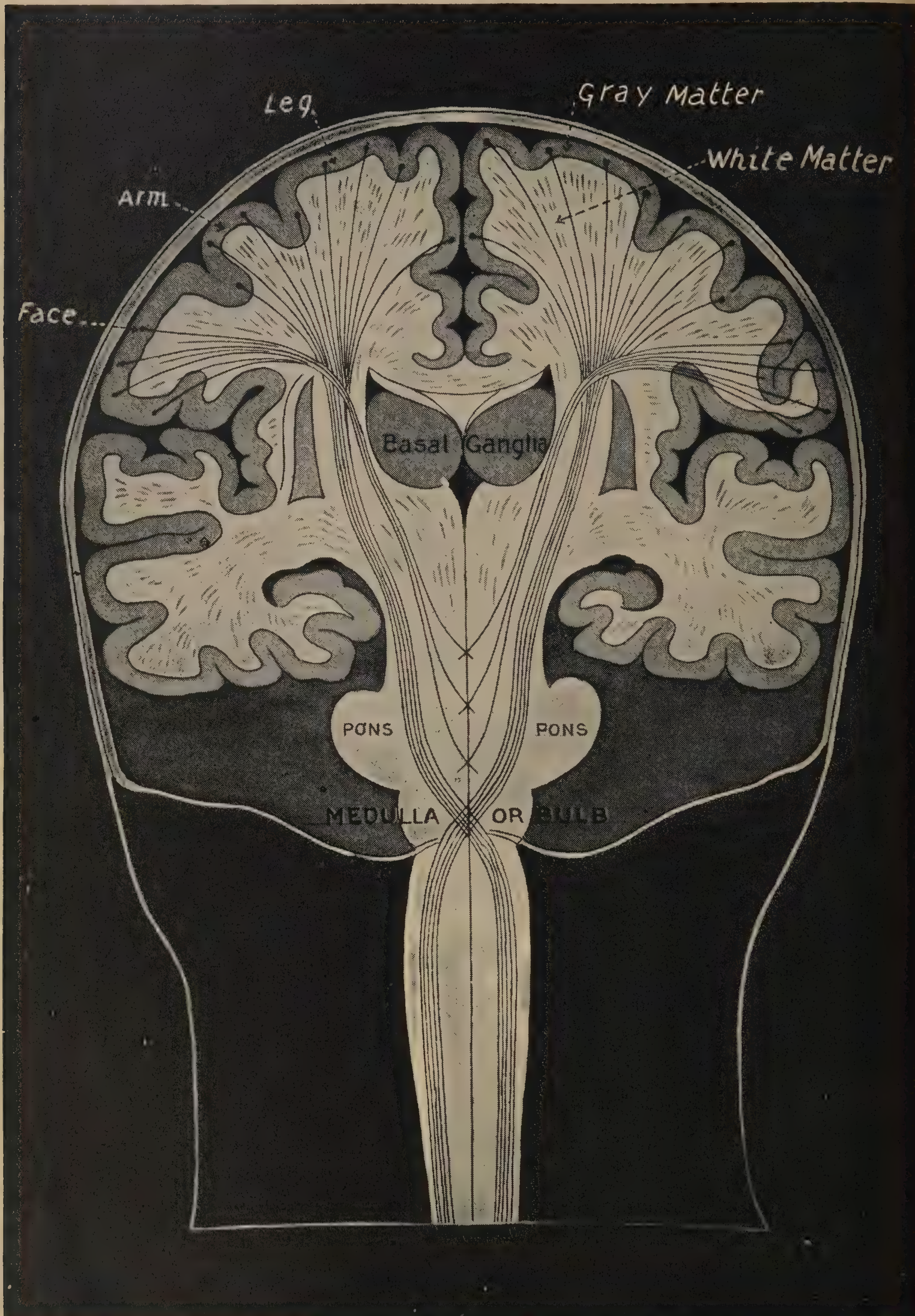
From the physical and chemical standpoint "a man is about 70 kilograms of *material*, with a certain configuration, properties and internal movements". From the physiological standpoint, he is a *living organism* blindly fulfilling its biological destiny. From the psychological standpoint, he is a *person*, the subject of purposive knowledge and volition. The religious and philosophical thought of the past has begun with this person. The science of today insists upon beginning with the "70 kilograms of material". Which is right?

The answer must be that no aspect of the truth must be ignored, and that both parties are right until and unless they begin to deny the truth which the other party begins with. And the reason why we must begin with the "physical and physiological accounts" is that very often we can get no further. Therefore this "physical and physiological account of man" can never be dispensed with, and the more complete we can make it, the better. *But* if our "physical and physiological account" not only stops short of the mind, but declares that the mind is a fiction, of which no evidence is found when we are dissecting structures in the abdomen or staining sections of the brain, then the half-truth we have found becomes worse than any ordinary lie.

From the first point of view, physical and physiological, the behavior of a man depends upon his physical environment, and on the blind physical or physiological processes occurring round and within his body; his perceptions and actions and his continued existence depend absolutely on the material and energy coming to him from the environment, and on the bodily structure transmitted to him from his parents. From this point of view no independent mind or soul can be distinguished, all psychical activity is dependent on the body and its physical environment, and is apparently a mere accompaniment of physiological changes.

But from the second point of view, which is that of everyday belief, of first-hand experience, and also of psychology, a

MESSAGE-CARRIERS FROM BRAIN TO BODY



This picture-diagram shows in simplified form how nerve-fibers cross in the medulla, so that the left side of the brain controls the movements of the right side of the body, and vice-versa. These fibers convey the impulses from the surface of the brain to cells in the spinal cord, and thence to the muscles

WHAT BRAIN STUDY SHOWS

The Astonishing Foldings of the Brain and the Activities that are Traced to Each

THE SWITCH BOARD THAT LINKS UP THE MIND

IF we weigh the entire brain, we find that the comparatively new development, called the cerebrum or great brain, comprises six-sevenths of the total weight. Of all this substance, however, only the much-folded surface really concerns us. As regards the folding of this bark or cortex of the cerebrum, we observe that it enables the cortex to have really no less than five times the area of the cerebrum taken as a whole. No wonder, therefore, that there is some relation between the degree of folding in different brains and the quality of their manifestations. But it is also to be noted that this method of folding the cortex is much better than merely thickening it would have been. Keeping the cortex thin, and folding it, had the advantage of enabling the nerves to get at it readily on its inner surface, and of enabling the tiny, innumerable blood-vessels from the innermost of the brain coverings to reach the cortex liberally and easily from its outer surface. It is to be remembered that the innermost brain membrane, the *pia mater*, dips into the fissures of the cerebrum, and thus follows the cortex in all its foldings.

Though every brain differs in the very small details of its surface pattern, yet the main unfoldings of the cortex are fixed in mankind, and are unfailingly transmitted by heredity in all normal brains, in every race everywhere. It thus becomes possible to prepare an average or constant map of the cortex, showing its division into a small number of lobes, having deep and constant fissures between them, and showing how each of these lobes is itself fissured, on the whole, in a constant way. Such a map of the left side of the cerebrum is shown on page 2093, with the frontal, parietal, temporal and occipital lobes clearly displayed. Each of these lobes corresponds, roughly, to the similarly named bones of the skull, shown on page 923. The importance of this preliminary mapping out of the cortex is extreme, for once we have gone so far, and find how constant are its main features, we find ourselves asking again the perfectly reasonable questions which were asked by Dr. Gall, the founder of phrenology, such a long time ago, and to which, in the state of knowledge at that time, only erroneous answers could be made.

In a word, we feel assured that there must be, in the brain as everywhere else in the body of man, or of any living creature, some correspondence between structure and function. May we not, for instance, be able to show that the occipital lobe is concerned with, say, vision, the temporal lobe with hearing, and so on? This is the great problem of what is now known as "cerebral localization", the attempt to localize the performance of certain functions in certain fixed and identifiable parts of the cortex. For this purpose we must, of course, consider the whole cortex, not only the outer surface, as shown in the illustration, but also its inner surface, which we see when we part the two hemispheres of the cerebrum, and look between them.

Our inquiries exceed in importance, for practical purposes in medicine and surgery, almost any that can be named, and for philosophy they far transcend anything else that science can attempt.

MEMORY AND ATTENTION

How We Retain Interesting Experiences, Recollect Them, and Recognize Them when They are Recalled

THE ART AND SECRET OF LEARNING

HAVING studied the facts of sensation, and the way in which we associate the impressions which we have derived from sensation, we have already had plenty of occasion to observe the vital property called memory. Only a few points need reference before we pass on to more difficult matters.

First, we have seen that, in the philosophical sense, all living things remember, and they alone remember. We are thus the sum and issue of all our past. Probably nothing is forgotten — somewhere. Once and for all, we sharply distinguish between the primary fact of memory, which is *retention*, and the secondary fact, depending on the first, which we call *recollection.* We all know quite well that, when we say we "can't remember", we mean that we cannot recall what, in fact, we know to be remembered somewhere within us. We say, "It will come back to me in a minute, though it has slipped my memory just now." Obviously, common speech here, as usually, confounds two distinct things, and on consideration we see that the process of retention and the process of recollection are quite distinct. Each of these two processes requires some comment, but first we must observe that there is a third process involved in memory, which we call recognition. We may retain, and recall, and then not recognize the memory in question. We may fail to recognize what, in fact, we remember, such as the face of someone who greets us with the infuriating observation, "I'm sure you don't remember me." There the word "remember" covers more meanings than one.

You do remember the face, in the sense that it has been retained in memory, for you know that you have seen the man somewhere before. But for the life of you you cannot remember where. In a word, the act of memory which we call recognition has failed. But if he follows up his ingratiating introduction by a series of hints — "Last summer", "The best of afternoon parties", "A tennis match" — at any moment the act of recognition may follow. Now let us note these three constituents of memory in their natural order.

Retention, the primary fact, is natural to all life, as we have seen, but its intensity varies. The degree of retentiveness is probably a native characteristic of the individual, and is to be treated as such. Disease or intoxication or senility or shock may diminish or destroy it. It varies in the course of the individual life. During some years before puberty, sheer retention is often extraordinarily accurate and easy. The child remembers names, poetry and so forth with incredible ease. Shortly this acuity diminishes markedly, and few adults can remember as they did in their teens, if by remembering we mean merely retention. In senility the decadence of the power to retain is very marked. The memory of the remote past remains, because the retentions were made by younger nervous tissue, but new retentions are made with difficulty, so that recent facts are not remembered, though remote ones, which we might think more difficult to remember, are accurately retained and reproduced. The explanation of this paradox is now apparent.

A SURVEY OF HYPNOTISM

The Different Levels of the Hypnotic State, and How They May Be Used and Abused

STRANGE EFFECTS OF SUSCEPTIBILITY

WHAT we have already learned of the subconscious mind will prepare us to study the facts of hypnotism with somewhat less indifference than the medical profession, as a whole, in this country has hitherto permitted itself. Here is a dominion of fact, not only instructive but of high practical value, which has until lately either been neglected altogether or else employed in objectionable ways. The medical schools have ignored it, notwithstanding the quality and authority of the Old World literature on the subject, which we owe to such men as Charcot and Liébault and Forel. In this country hypnotism, or, rather, the pretense of hypnotism, has been used largely to entertain the public in theaters or side-shows.

The first statement to make about hypnotism is that it is much too serious and important a matter for public exhibition, that public pretense of it is obviously objectionable and that actual hypnotic exhibitions in public would be worse, as being extremely likely to involve serious injury, sooner or later, to the mind and physique of the hypnotized person.

The only person who can benefit by such exhibitions is the real or pretended hypnotist. If he had exceptional powers, peculiar to himself and capable of performing great services for others, there would be a very urgent argument in favor of letting him exhibit them, however distasteful his success might be to more regular practitioners. But the first scientific proposition which we shall here make about the hypnotic process is that the hypnotist does not play the part which the public and his subjects suppose, and which, no doubt, many hypnotists in the past themselves supposed. The accepted idea is that the hypnotist hypnotizes his subject by means of some force resident in himself, and presumably allotted to him in rare and mystic measure. We cannot better understand this question than by briefly looking at the history of it.

We may begin with Friedrich Anton Mesmer (1733–1815), from whose name the word "mesmerism", an old synonym for hypnotism, was derived. He asserted, and very probably believed, that his results were due to a mesmeric force which emanated from himself; and it needs little imagination to suppose that such a force would be electrical or magnetic in nature, or allied to those mysterious and invisible modes of energy, about which we think we know a little. There is, however, not only no evidence that any "mesmeric" force of the kind exists, but also abundant evidence that no such force is needed for the production of the hypnotic effect.

Suppose, then, that we totally reject all ideas of any kind of *physical* force, or mode of energy, that passes between the hypnotist and his subject. There is an alternative. We may argue that the hypnotist produces his effect by a *psychical* force; and in order to confuse ourselves and our subsequent thinking as completely as possible we may call this psychical force, which the hypnotist employs, by the name of "will-power". It is argued, then, that the hypnotist indeed employs no physical means, visible or invisible, but he has an invincible will, to which all must yield.

INSTINCT AND EMOTION

The Deep-Seated and Universal Influence of Instinct, and Its Inseparability from Emotion

THE MODERN STUDY OF PSYCHOLOGY

WE are now about to plunge into what St. Augustine called "the abyss of the human mind". We have studied the senses, the memory, the mechanism of speech, and we have to look now at what Wordsworth called "the very pulse of the machine". It feels, is impressed, combines and retains impressions, but, furthermore, it does things. Why and how? All that we have yet dealt with is only preliminary, after all, though there are many textbooks which deal with nothing else, as if the intelligence were the whole of man. The intelligence is only a method, a mechanism, a mode of direction — for the purposes of that whose purposes they are, and whose intelligence it is. We must get down to the springs of action, to the very pulse of the machine.

In the study of reflex action, we saw how living creatures, including ourselves, may and do respond to stimuli. Light is felt, and the pupil of the eye contracts; a fist approaches, and the upper eyelid falls; we sit on a pin and rise rapidly, perhaps with a reflex expletive in addition. These are more or less simple reflexes, or reflex actions, and the study of them does not take us far enough when we want to understand the behavior of man. Nevertheless, we note that these responses, though in a sense automatic and mechanical, are yet not without meaning. They are for life. They express the intention and purpose and construction of the living thing *to live*. They are the mechanical expression of purpose, just like a machine, a gun, a locomotive or an electric piano, made by man and caused to "go" by means of the appropriate "liberating stimulus".

When we look at certain other kinds of behavior, evidently more complicated, such as throwing oneself into a fighting attitude or into another person's arms, or when we see a puppy or a child devoting itself to the examination of some novelty, we recognize a sort of resemblance to mere reflex action. These higher types of action we call "instinctive"; and we know that a vast variety of human behavior, in small things and in great, belongs to this class. It is instinctive, natural, follows impulses which arise within us, of which we are conscious, but which, in a sense, we cannot be said to have invented. We "find ourselves irresistibly drawn" to do this or that, as the moth flies to the light, or the infant's hand feels for its mother's bosom. If we believe in the doctrine of organic evolution, as we all do, we must try to trace and define a connection between those lowest forms of conduct by which, say, the amœba, "sensing" something edible, approaches it, and those by which a hungry man follows a sniff of an adjacent restaurant, or works night and day for money wherewith his children may be fed when he is dead.

The first, and in many ways the greatest, student of this subject was Herbert Spencer, whose "Principles of Psychology", has now passed its sixtieth birthday. Having recognized the theory of evolution to be a universal truth, Herbert Spencer sought to apply it to the evolution of mind. Thus he reached the conclusion that "instinct may be described as compound reflex action". In the simplest reflex a single impression educes a single response; in the working of instinct many

"I DO SET MY BOW IN THE CLOUD FOR A TOKEN OF A COVENANT"

DOUBLE RAINBOW. From a painting by G. A. Clarke, of King's College Observatory, Aberdeen, showing bright inner and faint outer bows with the space of relatively darker sky between

FACING PAGE 1680

Life

THIS section starts with the earth habitable, and the very beginnings of life in its simplest forms, and its irresistible advance towards the advent of man. It brings the story through the long ages when plant and animal life—often beautiful, often hideous—alone peopled the entire world of land, earth and sky, before their master was created to subdue them to his uses. It tells what life is, as near as we know, and what is the nearest we can come to producing it. The illustrations are a revelation of some of its mysteries.

The Germ-Plasm Theory

The study of heredity by Weismann

Justification of Weismann's theories by subsequently ascertained facts and by the experiments of Mendelism

The Revolution of Mendel

The life and work of a great monk

Experiments with the growth of peas in the abbey garden which changed the current of scientific thought

Strange neglect of Mendel's work while he lived

The Big Steps of Change

An Amsterdam theory of mutations

What two botanists, Hugo De Vries and Wilhelm Johannsen—a Dutchman and a Dane—have added to our knowledge of life

A Great Contemporary Leader

The analysis of formative units

The work of Professor William Bateson, master and founder of the school of genetics

Results so novel require time for interpretation

Mendelism Up-to-Date

Latest results of American tests

Why should not laws constant in relation to the propagation of plants apply to man?

A theory that equally explains new characters and reversion to an ancient type

Experimental Biology

Pioneer work of Loeb and MacDougall

The problem of external influence; is life formed wholly from within?

The study of radioactivity on germ-plasm in plant life

The Balance of Nature

Darwin supported by later science

For the theory of disease we must return to Darwinian principles

The enlarged view of the struggle for life revealed by the microscope

The Great Cycle of Life

The primal mastery in the green leaf

How energy from the Sun, through plants, serves both plants and animals

The passage of carbon back to the air from plant and animal

The Omnipresent Parasite

The place of parasites in disease

How animals accommodate themselves to parasites

Theories of how immunity from the parasite it harbors is reached by the host

On the Microbe's Track

Man's supreme physical benefactor

What the world owes Pasteur, the founder of bacteriology and the father of preventive medicine

Man's Most Deadly Enemy

A great discoverer's mistake

The double task of rescuing man and the cow from tuberculosis

People who can kill the bacillus for themselves

The Child's Lurking Foe

Raiding tuberculosis in its haunts

New knowledge about the beginnings of consumption, its detection and prevention

Thanks to Röntgen rays and tuberculin test the presence of the bacillus detectable at earliest moment

Man and the Mosquito

Defeating an ally of barbarism

Major Ronald Ross's discovery of the carrier of malaria

How the curse was wiped out at Panama

The Conquest of Disease

The Earth made habitable by science

The work of United States Army surgeons in mastering yellow fever

Cause and cure of the sleeping sickness

The Conquest of Pain

The old idea that pain purifies the soul

The various drugs that cause insensibility and how they were first brought into use

Freezing as a method of diminishing pain

Lister and Modern Surgery

Lessons of life of modern warfare

The story of experimental advance towards antiseptic surgery

Why more wounded in battle now recover than ever before and are able to return to their fighting units

The Doctors' Revolution

A plea for a department of public health

The success of the antitoxin treatment of diphtheria and how the serum is obtained from a horse's blood

Why the health of our neighbor is our business

Medicine of To-morrow

Rivalry of chemistry and the knife

Study of the chemistry of the body as the pathway of hope against cancer

The discovery of insulin by young Canadians

Control of Life by Man

The food problems as men increase

Man's triumphs dependent on the cultivation, not the destruction, of life

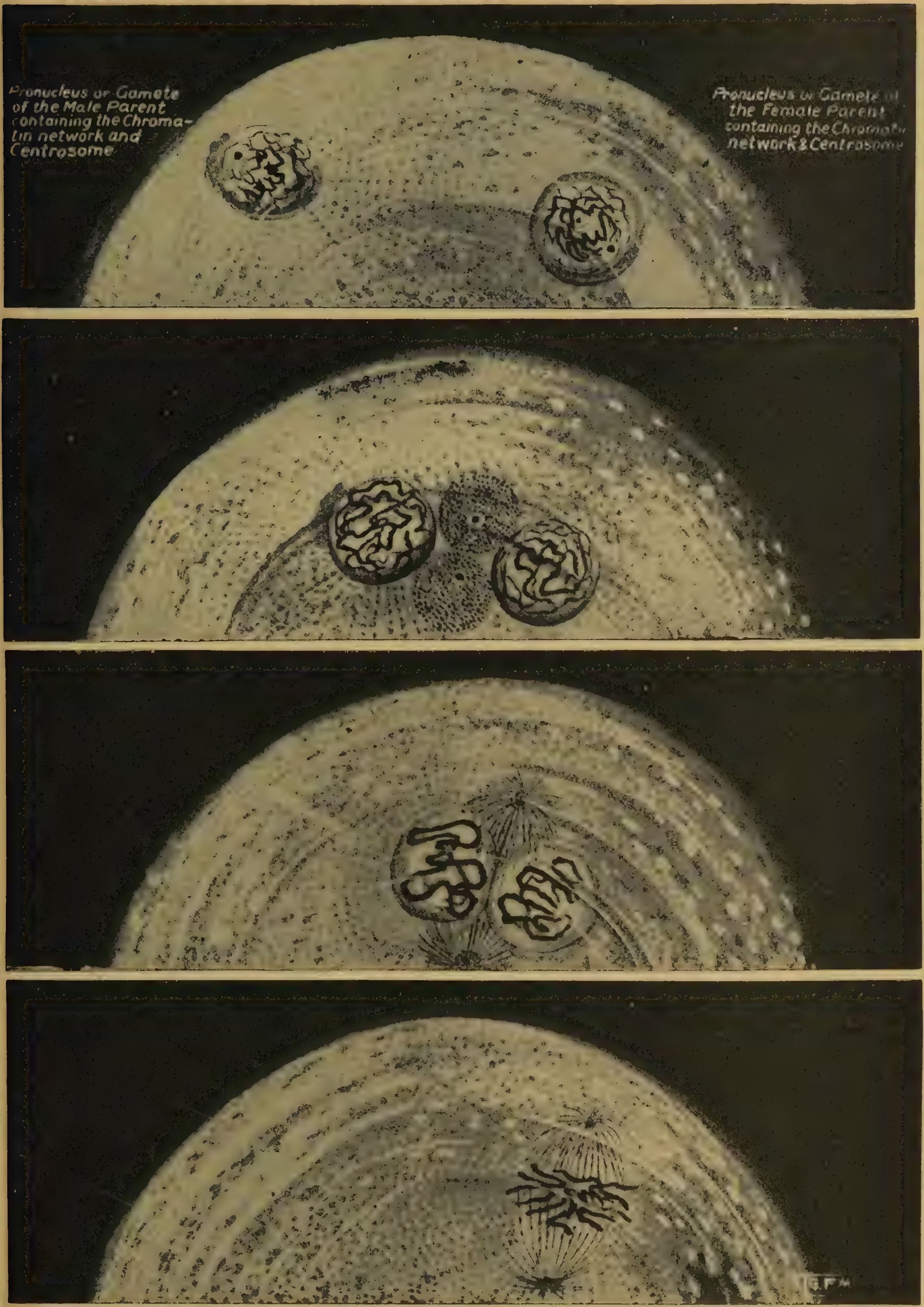
Need to prepare the way for more of his own species

Life's Ultimate Destiny

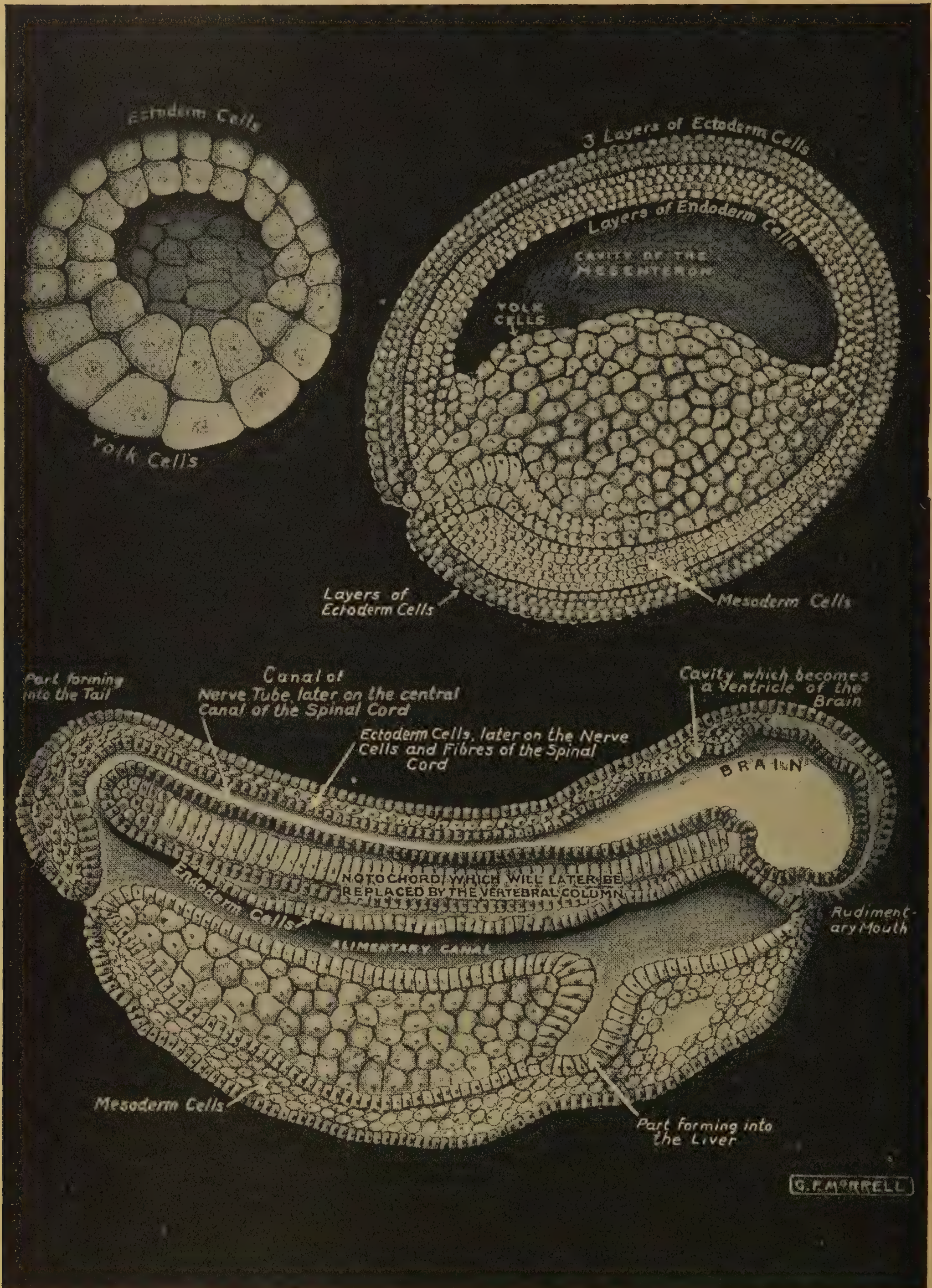
The discovery of inherent energies

The tremendous scientific case for personal survival

Unanimity of profound thinkers



These pictures represent the astonishing process by which is produced the first complete cell of plant or animal life. Shown here largely magnified, these cells are actually invisible specks, yet holding within themselves all the potentiality of life, all the characteristics of the individual, with its infinity of variations. In the top picture the cells are seen approaching each other, and, as they come together, the centrosomes of the two cells leave the cells, and, as shown in the second picture, begin to develop the achromatin filament which ultimately links them, as in the third picture. The chromosomes attached to each filament now combine to form the first cell of a new organism, and the union of the two cells has thus created a power that neither had before — the power of building up a new individual. The new cell has also the power of reproducing itself, as shown on page 618, until the organism is completely built up.



These pictures help us to understand the way in which living cells arrange themselves through the working of the mysterious forces of life into a complex organism. The artist has taken three stages in the early development of the embryo of a frog, beginning with the early cells, and showing how the three groups of cells — the ectoderm, mesoderm and endoderm cells — invariably produce certain specific parts of the organism. The drawing shows also how the brain, the spinal cord, the vertebræ and the alimentary canal are among the earliest parts to form, and it illustrates the way in which these simple cells group together, and form countless parts of any individual member of the animal world.

A NEW STUDY OF HEREDITY

Hereditary Resemblances and Hereditary Differences: Complementary Aspects of the Same Thing

AN INTRODUCTORY REVIEW OF TERMS

ALL truth is one, no fact contradicts another fact, and the smallest fact in the world may trip up the most imposing philosophy. Science, therefore, which is constantly trying to ascend from details to principles, from the present to the past and future, and "from the static to the dynamic view of things", is also constantly compelled to descend again to facts, to survey them anew, and add to their number without end. At the present time, for instance, a theory of evolution which was accepted for decades is crumpling into fragments before the contents of a pea-pod. We examine the individual peas, knowing their ancestry; and the great theory of evolution by the natural selection of minute random variations goes by the board. This outline suffices to indicate what is to follow.

The law of death, as we have seen, is one of the laws of life. The passing of the individual means that the species must be maintained by reproduction. The new individual, as a rule, does not resemble its parent perfectly — compare a human father and his baby boy, or an oak and an acorn — the reason being that the young creature undergoes a period of development before it reaches maturity. In this developmental period all sorts of strange things are apt to happen; above all, in the case of the insects, the young butterfly appearing from the egg *not* as a butterfly, but as a wingless, creeping caterpillar. All these stages have to be studied and explained, if possible. But, as we study and explain them, we are impressed, above all, with the chief outstanding fact that the offspring resemble their parents at some stage or other, and that resemblance we call "heredity".

This resemblance is an essential fact of the life-history of species, for there could be no such thing as a species without it. Equally essential is it for any theory of evolution, or for any theory which denies evolution. If we deny evolution and accept special creation, we still avow a belief in heredity, for we declare that existing forms of life are just as they were made by Deity long ages ago. But we do not therein assert that Deity made the forms now alive. We know those were derived from parents, and those from parents, until the "first parents" made by "special creation" are reached. The identity between existing forms and their first parent thus depends upon the most unreserved belief in hereditary resemblance. No evolutionist has such in "heredity", in this sense.

But though he cannot be so entire a believer in heredity as the special creationist, yet he must base all his teaching on the fact of heredity. Certainly he knows that if there were *nothing* but hereditary identity between parents and offspring there could be no evolution, no change of species, no invention of new species. But while he is therefore compelled to assert the fact of hereditary difference, he also believes in hereditary resemblance, for without it species would not exist. If the offspring of human parents were equally likely to be sweet-peas, white rats, or babies, the world of life would not be the world of life we know. But the evolutionist is absolutely dependent upon the details of heredity for any chance of framing a true theory of the *how* of evolution. And that is just the very *crux* of biological controversy at the present time.

THE EVER PULSING STREAM OF LIFE

Living Blood always Circulating and Constantly Transformed Carries the Body's Supplies and Repairs its Defenses

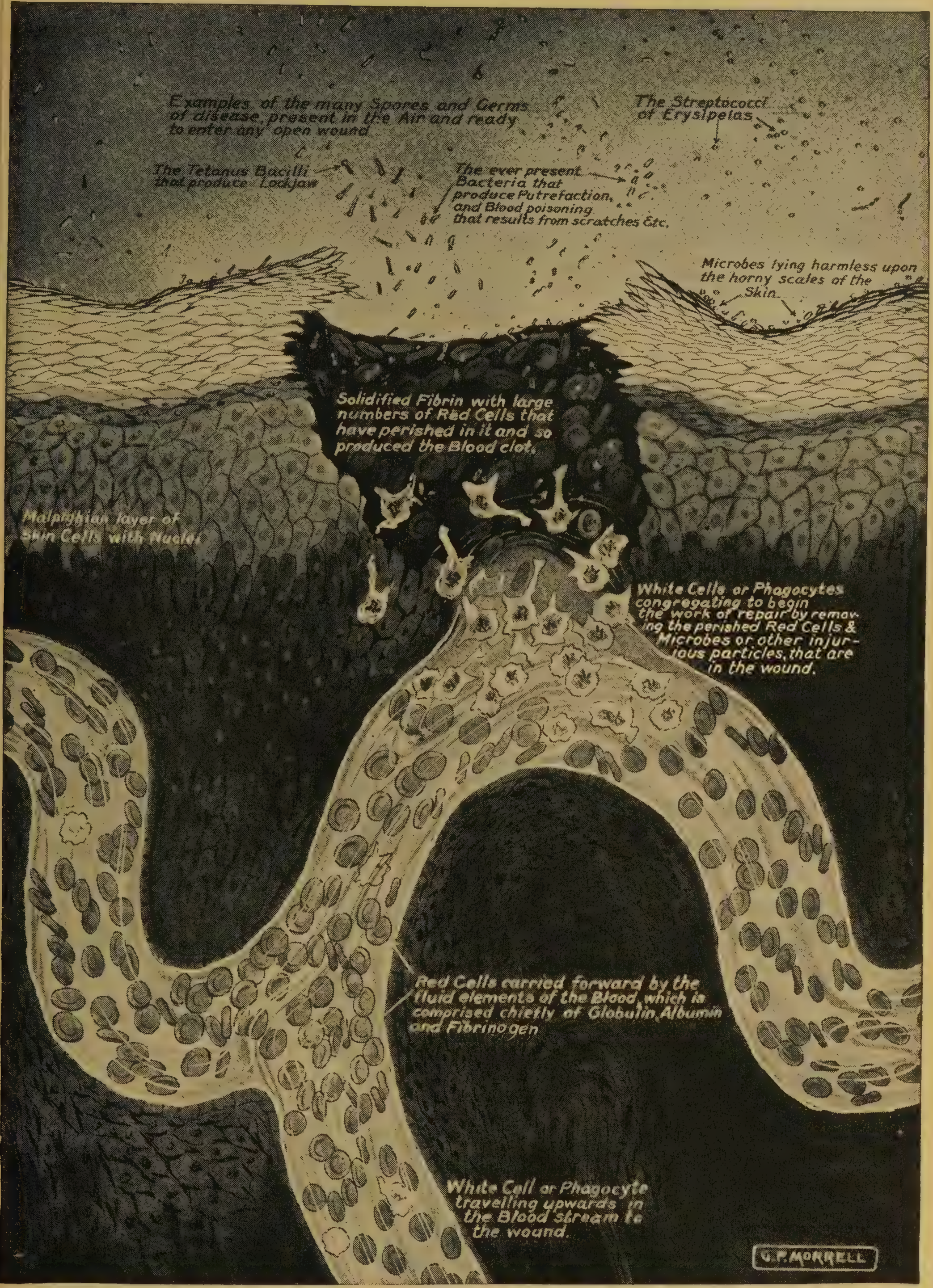
MAN'S BLOOD AS PERSONAL AS HIS FACE

THE body of man, like that of most animals, is provided with a complicated mechanism, of pump and tubes and nerves, for the circulation of a fluid called the blood. If the circulation ceases for more than a few seconds, we die. Thus, though there is no real meaning in the familiar phrase that "The blood is the life," the blood is necessary to life, and, further, its continuous motion is necessary to life. We may add that the blood is itself alive. Though it is fluid, and not a definitely fixed tissue, such as muscle or brain tissue, yet it comprises living cells as they do, and in quite as high a proportion to the rest of its composition. Its living cells do not enter into any mutual relation, and are not fixed, but we must call the blood a tissue; for it is at least as crammed with life as any tissue or organ of the body, and we should beware of being deceived by its fluidity. The blood can become a solid at any time, and is never more valuable and more alive than when it does so at the proper time and place. A portion of solid or clotted blood, actively engaged in reparative and constructive work — a tissue-maker, indeed — cannot possibly be denied the title of a living tissue which we grant to brain, or gland, or muscle.

There is a marked contrast in this respect between blood and such a fluid as milk, which is manufactured from the blood. The fluidity of both is deceptive, and only for convenience. Each can readily be solidified, and in that form gives us a much better idea of what it really is than when it is in the fluid state. We then realize that each contains a quantity of solids dissolved in water, which is true of all tissues. But though milk contains globules of fat it contains no living cells; and solidified or clotted milk cannot be called a living tissue, nor liquid milk a "vital fluid," as is too commonly done. Clotted blood, on the other hand, such as binds and repairs a wound, is a living tissue, if anything is; and liquid blood is a "vital fluid," in the fullest sense of the words, so long as we do not mean that the fluid part of the blood, in which its cells swim, is itself alive.

We cannot contemplate the circulation without guessing that the fluid which requires to be unceasingly moved on is so moved in order to undergo changes. Evidently something must happen to it. If for instance, every red blood-cell must pass through the lungs, say once a minute, it must either give or get something there, and be thus different according to whether we examine it in a pulmonary artery or a pulmonary vein. This general assumption about the circulation of the blood is proved by the simple observation that the blood in an artery and the blood in a vein differ in color. So marked and important is the difference that we speak of arterial blood and venous blood, the former being bright and red in color, while the latter is duller and of a red which, in the vessels, appears all but blue. We observe the color of venous blood in the face of anyone whose venous circulation is being obstructed by great cold or heart-disease or fury, or even a tight collar. Plainly, therefore, there is some radical distinction between arterial and venous blood and we cannot describe "the blood" as if it were a single, constant fluid.

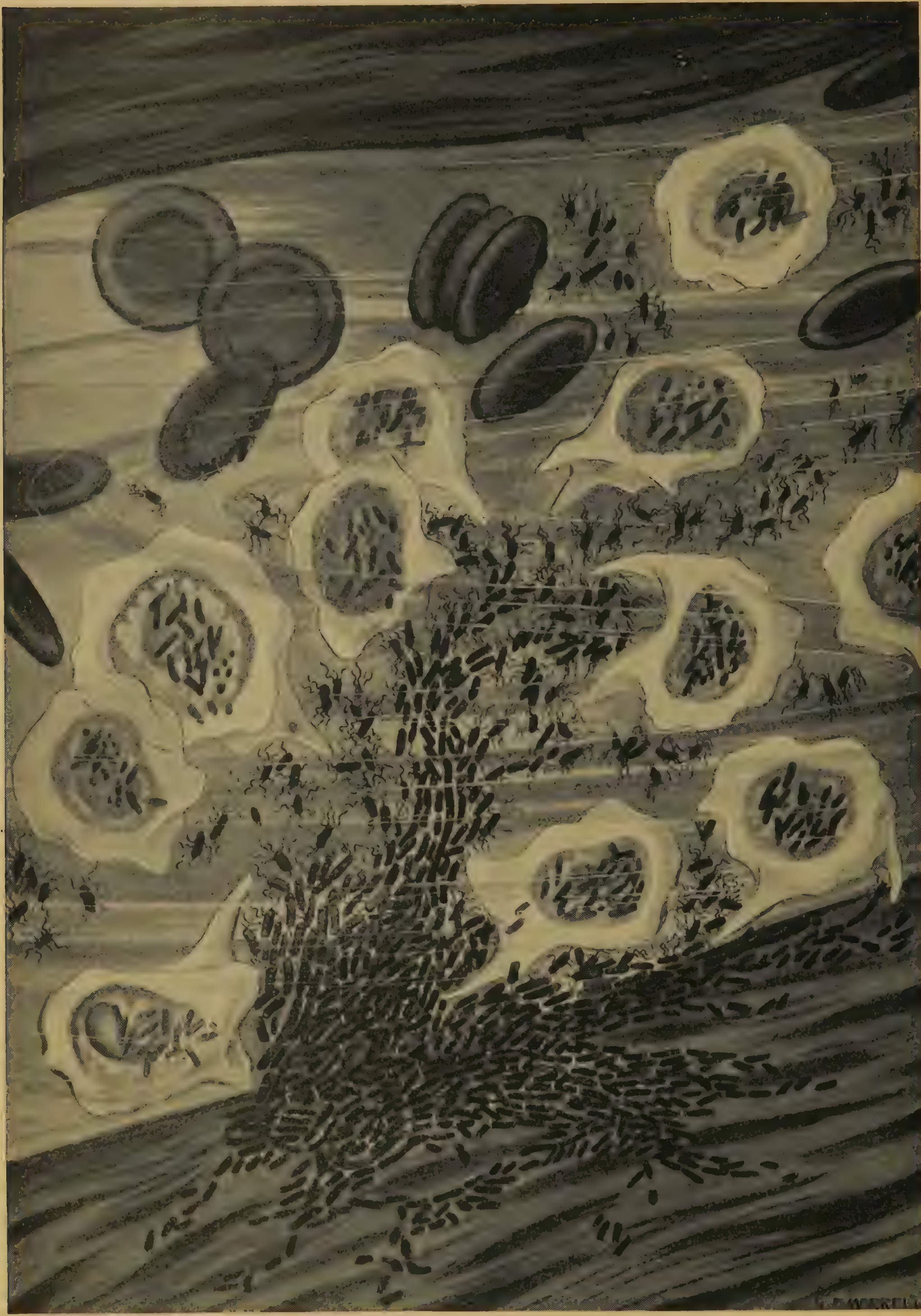
THE HEALING POWERS OF THE BLOOD



THE SENTINELS OF THE BLOOD HEALING A TINY WOUND AND DESTROYING THE INVADING MICROBES

This picture-diagram represents a greatly enlarged section of the skin, about one-sixtieth of an inch thick, with a tiny scratch sufficient only to tear open one minute capillary. On the one hand are shown the dangers from various forms of septic bacteria ever present in the air, and in contrast the marvelous provision of the blood and its many elements to protect the body by destroying intruders and allow the healing of the wound to proceed. Thrombin forming in the blood stops the bleeding by transforming the element fibrinogen into the solid fibrin of the blood-clot. For the sake of clearness the capillary and the red and white blood-cells within it are drawn larger in proportion than the tissues of the skin.

HEALTH AND DISEASE IN DEADLY COMBAT



THE BATTLE IN A DROP OF BLOOD — WHITE CELLS BREAKING UP THE TYPHOID FEVER PARASITE

After looking at a drop of blood through a microscope, Health and Disease are realities for the rest of the spectator's life. Here is what he sees in a patient suffering from typhoid fever — the wonderful white cells attacking, swallowing, killing, digesting, or utterly breaking up the black parasites which mean disease. If the wonderful white cells win, the patient recovers; if, however, the parasites win, he dies.

SELF-POISONING BY FOOD

The Tragedy of the Prosperous Man who Shortens His Days by Indulgence

SIGNS OF AGE AND HOW TO MEET THEM

IT is, of course, the hygiene of the mind at which we have been aiming in all the foregoing discussion of bodily health. That discussion was necessary for the sufficient reason that the brain is a physical structure and is the organ of the mind. In our discussion of exercise, alcohol, diet, ventilation, we were all the time concerned with the effect of such things, not upon the bones or muscles, but upon the brain and the mind. In the last chapter we endeavored to trace the conditions of mental health in childhood and early adolescence. Now we have before us the problem of the adult; and the first fact we notice is that no sooner is man adult than he begins to grow old, at a less or greater pace.

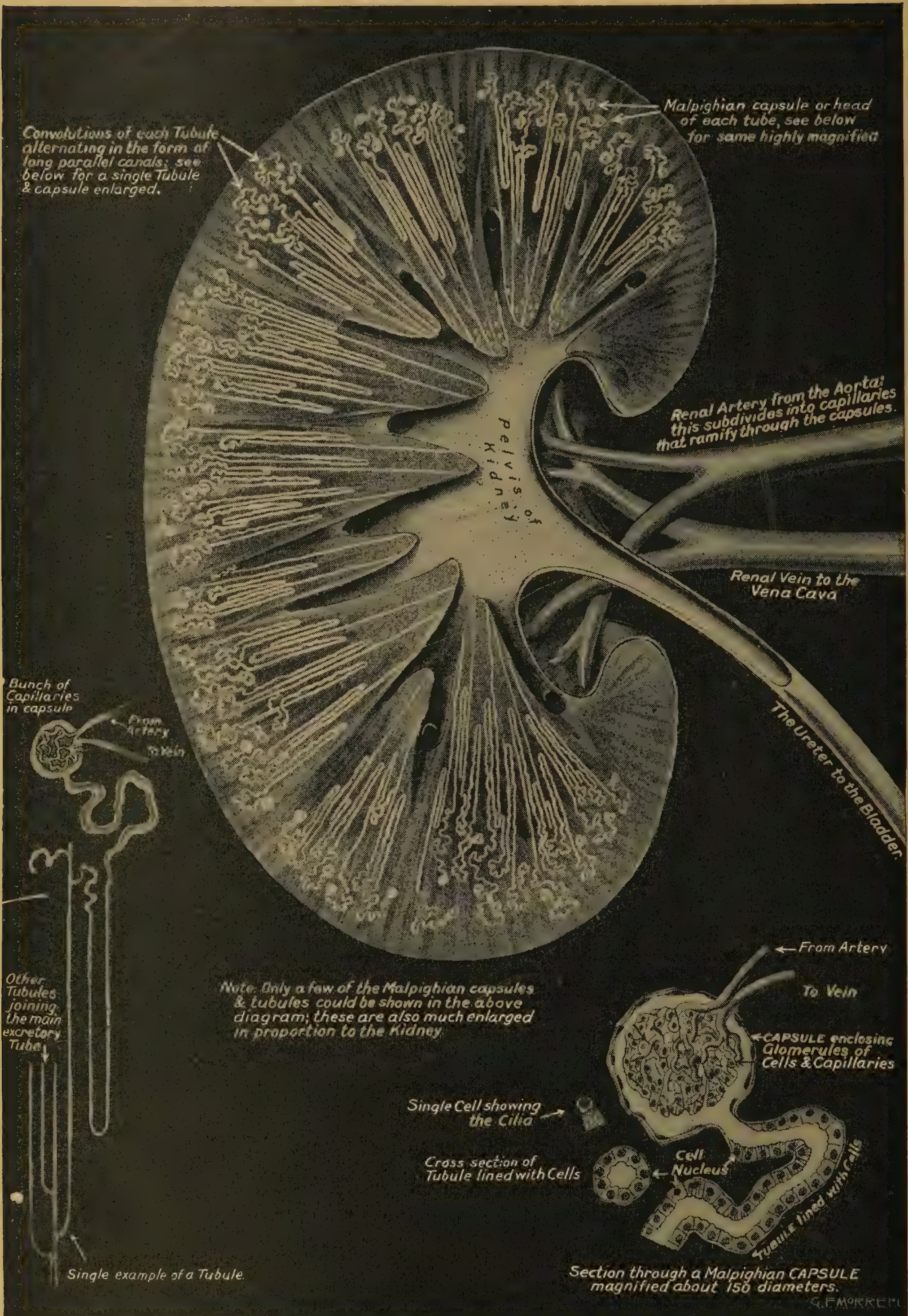
From birth onwards the body continues to change. There is no stationary period. No year passes and leaves us the same. As Professor Arthur Keith says, the skin of the face and the muscles of expression that lie under it are the most accurate register of years. "Not one passes and leaves the skin just as it was; every year the tender, soft, suffused, velvety covering of babyhood moves one degree towards the dry, gray, wrinkled and loose integument of the very aged." A complete human life is made up of two distinct periods, one marked by the ascendency of growth and the other by the slow assertion of decay. Where the first period ends, about the twenty-fifth year, the other begins.

These are the physiological facts which the hygienist has to reckon with; otherwise he will soon be mistakable for a charlatan, promising or assuming the impossible. But let him further note that the normal age-changes of the body do not progress with equal speed in all its parts. The elastic tissue of the skin and of the coats of the arteries is the first to age; hence the tell-tale nature of the skin, and the fact that the short-distance runner, for instance, begins to lose his speed after the twenty-fifth year or so. But the brain is at its best as the controller of muscular action between thirty and forty, and as an organ of thought, probably between forty and fifty, in spite of Dr. William Osler's much quoted (and distorted) remarks about "the comparative uselessness of men over forty", and in very great contrast to our assertion about the arteries and the power of making violent physical efforts.

Yet we do not all grow up, or grow old, at the same rate, and all mankind, and womankind no less, appeals to the hygienist for the maintenance or the restoration of youth. This is what the alchemists sought for so eagerly, an "Elixir of Youth" that should stay the advance of the Man with the Scythe. In recent years great attention has been paid to this subject, and many writers, such as Metchnikoff, Forel and the late Sir Thomas Clouston, have contributed to our understanding, and even to our control, in some degree, of the problem.

It may fairly be said against these distinguished writers that they fail fully to appraise the importance of natural differences in this respect, alike between species, races within a species and individuals within a race. Longevity is largely a natural character, depending upon native constitution.

OUR CHIEF ORGAN OF EXCRETION



These picture-diagrams of the human kidney show graphically nature's marvelous mechanism to rid our blood of its waste materials. Each successive diagram shows a smaller portion of the kidney under higher magnification, thus explaining more clearly the structure of this wonderful organ.

DRESS FOR A THOUSAND YEARS

Doctor–800 A.D. Lady–950 Soldier–1000 Noblewoman–1050 Gentleman–1100 Countess–1200

Gentleman–1350 Gentleman–1360 Courtier–1400 Citizen–1400 Lady–1450 Nobleman–1450

Gentleman–1450 Dandy–1480 Lady–1480 Courtier–1480 Lady–1480 Noblewoman–1490

Gentlewoman–1490 Nobleman–1490 Laborer–1500 Merchant–1500 Soldier–1500 Merchant–1520

DRESS FOR A THOUSAND YEARS

Housewife–1520 Dandy–1530 Nobleman–1530 Nobleman–1550 Gentlewoman–1550

Lady–1560 Servant–1560 Nobleman–1570 Gentleman–1570 Housewife–1570

Nobleman–1580 Countess–1600 Prince–1600 Duchess–1650 Puritan–1650

DRESS FOR A THOUSAND YEARS

Lady–1650 Nobleman–1650 Nobleman–1660 Gentlewoman–1660 Nobleman–1670

Lady–1670 Gentleman–1680 Nobleman–1680 Prince–1680 Lady–1690

Lady–1700 Gentleman–1700 Merchant–1700 Lady–1710 Lady–1750

DRESS FOR A THOUSAND YEARS

Dandy–1750 Gentleman–1760 Lady–1770 Young Lady–1780 Lady–1780

Lady–1790 Gentleman–1790 Lady–1800 Lady–1815 Squire–1815 Farmer–1815

Dandy–1821 Lady–1823 Lady–1830 Gentleman–1836 Lady–1852

Health

THIS section of The Book of Popular Science is not a "family doctor," with a suggested remedy for every ill to which mankind is heir. Rather it points the way to retain the health that is his natural heritage. The insidious microbe, the self-made poisons, are described and pictured, but the object of the chapters is to show us the kind of surroundings in which we should live; the kind of air we should breathe; the kind of play with which we should temper work; what and how much we should eat; what we should drink, and the clothes wherewith we should be clothed. An intelligent following of the rules laid down makes for a long and happy life and few calls on doctor or druggist.

The Truth about Tobacco

The undoubted evil of drugs

Inhalation the special and serious danger in the cigarette habit
Effect of smoking or non-smoking on baseball players' throwing
Interesting experiments by the chief executive of the Boy Scouts of America

The Cup that Cheers

The truth about coffee, tea and cocoa

The inexact use of the word "stimulant" to indicate antagonistic effects
Unlike alcohol caffeine a pure stimulant with no second stage of depression

Problems of Alcohol

What becomes of it within the body?

Its importance as a chemical compound when used outside the human body
Alcohol in sufficient concentration fatal to all forms of life
The presence of alcohol in the body no warrant for putting more there

The Demand for Alcohol

Keeping a balance in nature's bank

The difference between thirst and craving
The true test of thirst the desire to drink water
The abstraction from the body by alcohol of the water needed by the blood

The Effects of Alcohol

The story of an unholy alliance

Evidence that alcohol lessens the power of resistance to disease
The effect of taking a drink of whiskey on a cold winter's night

Alcohol and the Brain

Treatment of the drink craving

The difficulty of making observations on oneself with fairness
The beginnings of prohibition in this and other countries
What honestly conducted institutions may accomplish in reforming the drunkard

Milk as a Food

A liquid with solid nourishment

Why cows' milk is now generally modified for infants' food
Certified and pasteurized milk; pasteurization in the home and at the dealer's
Milk estimated to furnish 16% of the national dietary

In Praise of Plain Bread

Wheat as the world's cheapest food

The superiority in all respects of crust over crumb
Some doubts about the arguments for brown and entire-wheat breads
Valuable forms of wheat that are known under other names—macaroni, vermicelli, etc.

Some Problems of Diet

The kind of foods needed by the body

What we should eat and when and how we should eat it
The fuel foods; the building and repair foods, salt-like foods

Further Problems of Diet

The amount of food we require

The mechanical efficiency of the human body
Energy requirements of brain workers and office workers the same
A baby's digestive powers three times that of an adult, weight for weight

The Pathway of our Food

The protective power of dentistry

Chronic affections directly traced to infection of carious teeth
The proper uses of small tooth brushes and simple dentifrices
The great importance of establishing regular bodily habits

The Care of the Senses

The cheapness of sound treatment

Practical hints on the preservation of comfortable sight and unimpeded hearing
The absurdity of assuming national degeneracy because of prevalency of short sight

The Health of the Mind

Country or city life for children

The need for keeping the child childlike, without forcing its mind
The unwise opposite extreme of suppressing natural curiosity

Self-Poisoning by Food

Signs of age and how to meet them

The tendency of obesity to lower men's mental activity
"A man is as old as his arteries" truer than many an epigram
Age a state of the soul not measured by time

The Gentle Path to Age

The maintenance of mental youth

The knack of growing young in the company of youth
Necessity for always learning that the mind may go forward

Health in Childhood

General principles and special hints

The grave mistake is unnecessarily early weaning
Proper manner of feeding the baby after weaning
The fatal theory that children must "have" childish diseases

Our Self-Made Sicknesses

What health insurance hopes to do

The ultimate dependence of individual and public health on private conduct
The bad citizenship of people who do not care for their health

WRONG AND RIGHT EXERCISE

Dangers and Advantages in Athletics — How to Strengthen Without Injuring the Body

TRUTHS AND FALLACIES ABOUT EXERCISE

THE evil results of over-athleticism in schoolboy and undergraduate days has so often been called to the attention of the public that it should now be thoroughly warned against these dangers. The necessary reaction against this long-continued excess is now beginning to be in evidence; and we may therefore confine ourselves almost entirely to the discussion of the science of the matter which, particularly, is of very high physiological interest.

In our present analysis and explanation of the evils of over-athleticism, we shall definitely divide them into two categories — physical and mental. It has already been argued that, for the philosophic hygienist, the influence of anything whatever upon the mind must be the final criterion. Yet even for those who do not admit so much, and who argue that not only the first, but also the last, need is "to be a fine animal", let it be noted what a very unsatisfactory kind of animal over-athleticism produces, quite apart from any injury to the mind. The methods of physical development which ruin the most essential parts of the physique, from the heart onwards, surely stand self-condemned. The truth is that even physical exercise requires to have brains put into it, unless its own ends are to be defeated.

Most of the voluntary muscles of man are almost daily becoming less important, as modern invention supersedes them. But certain of the involuntary muscles retain, and must always retain, their primeval importance. Of these, the foremost is the heart, far and away the most important muscle in the body.

The remarkable lack of brains in modern notions of exercise, so unlike those of the ancient Greeks, is nowhere better illustrated than in the pre-war drill regulations of the British army, wherein no end of trouble was devoted to enlarging the size of the soldiers' chests. A series of disastrous exercises was invented, which made the chest abnormally rigid in a state of sham expansion, which evolved very serious strain upon the heart. After many years, when many thousands of recruits had had their hearts damaged more or less permanently by this absurdity, the regulations were altered. But they remain as an admirable illustration of the wrong type of physical exercise.

The whole and only value of the chest is that it shall be mobile. Its value is not in its absolute dimensions, small or great, but in the difference between its maximum and its minimum dimensions — a difference which physiologists term the "vital capacity". As we get on in years, the chest always slowly but surely enlarges, owing to the gradual loss of the elasticity which should restore it to its smallest size in the course of each expiration. This ultimately leads to stagnation of air and blood in the lungs, and strain upon the heart.

But if this be the kind of evidence which we find when we study the young man, what shall be said of the evils of over-athleticism in the growing boy? Here, of course, the evidence is not merely similar but still more serious. In some of our modern girls' schools the great effort is to imitate boys in every particular, to play all boys' games, and play them hard, often without proper adaptation for the girl.

"A FAVORITE CUSTOM" — FROM THE PAINTING BY SIR LAWRENCE ALMA-TADEMA, R.A.

The baths of the Romans were probably the largest and most luxurious in the world's history some of them having a capacity for three thousand bathers. A perpetual stream of water was poured into the capacious basins through the wide mouths of lions of silver. "To such a pitch of luxury have we reached," says Seneca, "that we are dissatisfied if we do not tread on gems in our baths."

Reproduced by permission of the Berlin Photographic Company

BATHING AND SWIMMING

One of the Imperative Decrees of Health and the Art that brings Us Back to Nature

HOT AND COLD, FRESH AND SALT WATER

SINCE all life is lived in water, as we know, and since it is certain that the body is always losing water, a new supply is always required, especially as our power of storing water is very small, and disastrous consequences follow when we store more than a very limited quantity. Our needs in this respect are shared with all forms of life, but we further resemble other high forms, such as trees, in that we no longer take water in at all points, but only by a special channel. The tree is rained upon or we may be drenched to the skin, but neither of us takes in one drop of water in consequence.

First of all, therefore, we must study the laws of health in regard to external water — water which never enters the body at all, but may affect it. We have only to remember the mysterious company of ailments conveniently, and ignorantly, called "rheumatism," and their connection with damp states of the air or of one's clothes, to see that water outside the body may affect it no less than water inside it.

In all the air we breathe there is water-vapor, as one of its normal gaseous constituents, and this we take in with the rest. But as we always give out more, in each breath, than we took in, evidently the body receives no water from the inspired air. It does not follow that the water in the air is of no consequence. On the contrary, its quantity affects us deeply. Strictly speaking, what matters is not the quantity of water in the air, but the proportion of it, in comparison with what the air can possibly hold. The warmer the air is, the more water it can hold; and a warm air may thus contain far more water than a cold.

But the thing that matters to us is that the cold air, perhaps, is filled with water, or saturated, whereas the warm air, though holding far more, has not exhausted its capacity. We therefore require to introduce the idea of a relative humidity of the air to express its proportion of actual to possible moisture at any given temperature.

This question of relative humidity is of unceasing importance to the meteorologist, who is constantly concerned with the instruments that register it, and finds its consequences everywhere. But we have now learned that it is of no less importance in matters of health. The body must continuously lose water if it is to live; the process is exactly and entirely as essential as the need for the continuous intake of water. But while the task is largely undertaken by skin and breath, and is easy and rapid when the relative humidity of the air is low, of course it is hampered when the relative humidity is high.

Within the last few years experiments have been carefully repeated, under the supervision of the most competent medical experts and scientists, which prove conclusively, by exact observation on man, what has hitherto been only presumed. We now know that one of the chief causes of fatigue, headache, depression, lack of appetite and subsequent anæmia, following exposure to confined air, is the fact that such air soon gets loaded up with moisture, and then retards our loss of it. The subject is so important, and will require to play such a part in future reforms of housing and ventilation, that we must return to it again and again.

If plague had as often been brought to the great commercial centers two centuries ago as it is nowadays, our ancestors would scarcely have escaped. But now, when it reaches London or Liverpool, New York or San Francisco, it scarcely gets any further, because exact knowledge, applied to the problem, bars the way.

In India the plague is formidable and tragic. European science and humanity have not been entirely idle. Methods of prevention and treatment, dependent upon the preparation of special substances from the bacillus itself, have often proved useful, even on a large scale. But before diseases of this type can be eradicated India will have to have something like the system of primary sanitation which we have here. That time is still incalculably distant, but meanwhile the knowledge regarding the flea and the rat can be applied in some degree, and the spread of epidemics can thus, at any rate, be checked.

THE TSETSE FLY, *GLOSSINA PALPALIS*, THAT CARRIES THE TRYPANOSOMES OF SLEEPING SICKNESS

But we have not yet done with biting insects, nor with the animal parasites they convey. Once widely spread over the temperate and tropic zones was a disease called "relapsing fever", now confined to districts where there is much overcrowding and dirt. Since 1873 it has been known to be due to a spiral-shaped organism, a kind of animal parasite not unlike the "spirochæte" of syphilis to which its discoverer, Obermeier, a German, gave the name *Spirochæta recurrentis*. In the United States some observers had shown that Texas cattle-fever, or "red-water fever", is propagated by the bites of ticks. In 1904, two sets of investigators proved, in Africa, that relapsing fever is distributed by the bite of a special tick, and now we call the disease tick-fever. Drs. Dutton and Todd went on to show that the spirochæte can pass from the infected tick to its eggs, so that the larval ticks which hatch from them become infected, and a kind of epidemic is produced among the ticks, which can subsequently infect man. Pasteur, many years before, had shown that the same thing happens with the parasite of silkworm disease: the infected moth transmits it to her eggs, and so the disease proceeds. It was while working out the same facts in respect to the parasite of relapsing fever that Dr. Dutton became infected with the parasite and died of the disease.

Having got so far with fleas and ticks, we begin to guess that there is even more to be found. What about the cockroaches, beetles, lice, etc.? May not diphtheria, scarlet fever, typhoid, typhus and many more similarly be conveyed by insects? Must we not suspect vermin of all sorts?

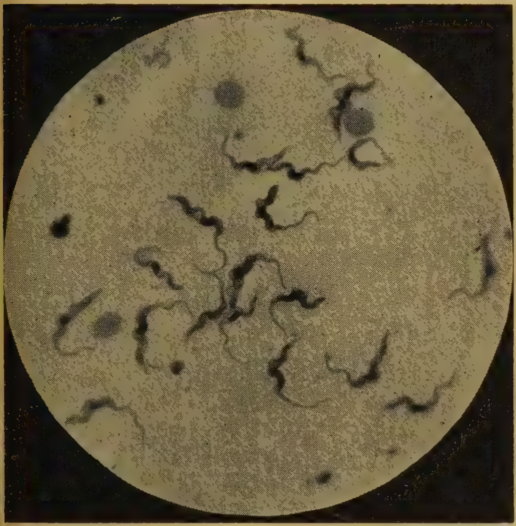
The domestic fly, *Musca domestica*, does not bite. We have always had it with us, and we regard it as a necessary nuisance. But after what we have learned about mosquitoes, tsetse-flies and fleas we require to study the fly more closely. It is now known that the fly conveys disease. Dr. Beauperthuy guessed the truth nearly two generations ago. Dr. L. O. Howard, Chief of the Bureau of Entomology, of the U. S. Department of Agriculture, has called the ordinary domestic house-fly the "typhoid fly", and the only objection to the name is that the fly conveys too many other diseases for it to be adequate.

But in any case it is true that the facts of parasitism play a very large part in evolution, and in the distribution of living forms. To take our own species as simply one among millions, evidently its geographical distribution has depended in the past, and depends at the present moment, upon the distribution of certain parasites. Where they abound, man is absent, or is found in only very small numbers. Mere physical conditions trouble him little. He penetrates everywhere, as all species try and tend to do, but the barriers which he cannot penetrate are those set up by parasites which would destroy him. Within those barriers there may exist certain small numbers of men, either degenerate or else specially adapted, and resistant within limits, but a non-adapted race cannot pass them without heavy penalties. On the other hand, members of the race within the area of parasites may be removed, and then multiply amazingly, like the negroes in the United States. What is true of man is true of many other species of animals and plants. If we examine their distribution and its limits we find that they are determined by the presence, beyond those limits, of creatures which would become parasitic upon them. Under the conditions of nature, things have mostly adjusted themselves. Perhaps a species has become resistant, in any or all of the ways we have discussed. Or else the species simply does not occur where the parasite or the potential parasite occurs.

On the whole, then, the fact of parasitism does not connote any appreciable quantity of disease in a state of nature. The internal characteristics of species, host and parasite, and their distribution, are so evolved that, in general, disease exists to only a very small degree.

But this we begin to appreciate only when we observe the consequences of any interference with the existing adaptation. We modify our own conditions, as in the formation of great urban aggregations, and promptly find ourselves the victims of many parasites. We penetrate to places where our race has undergone no evolution — Darwinian, Lamarckian or other — and again the result is disastrous. We take our horses with us to serve us, and find them the victims of an infection, transmitted by a blood-sucking fly, to which the native animals are practically immune. Just the same happens with many of the plants which we desire, and introduce into novel situations.

The work of the last few years, beginning with the labors of Sir Patrick Manson and Sir Ronald Ross, now a long time ago, has given us a general picture of parasitism



TRYPANOSOMES TRANSMITTED TO HORSES AND CATTLE BY TSETSE FLIES

TRYPANOSOMES OF SLEEPING SICKNESS TRANSMITTED TO MAN BY A BITING FLY

MEDICINE OF TOMORROW

Revolutionary Changes that are Proceeding Alike in Surgery and in Medicine

RIVALRY OF CHEMISTRY AND THE KNIFE

FOR once, here is a case where we may prophesy, because we know. The future developments of medicine are already crowding upon the present, and none can doubt them. The sooner we are prepared to understand them, the sooner they will be realized. First, let us observe the paradoxical fate of antiseptic surgery, the great surgical method which we discussed in a former chapter. Here is the most beneficent achievement of the human mind coming to its maturity within a generation, when all preceding generations had gone without it; and now it is about to undergo the most extraordinary decline in its scope, after threatening to supersede all other forms of treatment.

Hitherto, in its brief and brilliant career, antiseptic surgery has advanced from one part of the body to another, and from one type of malady to another, until mere medicine, the future of which we propose to discuss, threatened to disappear altogether. The surgeon has advanced from the limbs to the trunk, from the abdomen to the cranium, and from the cranium even to the heart, until it seemed as if the knife were to be Life's best champion. Even where organs had degenerated, like the kidney in Bright's disease, and were tightly strangled in their capsule made thick and rigid by long inflammation, the surgeon has tried to strip off the "strait-jacket" of the gland, and so to restore its blood-supply and its health.

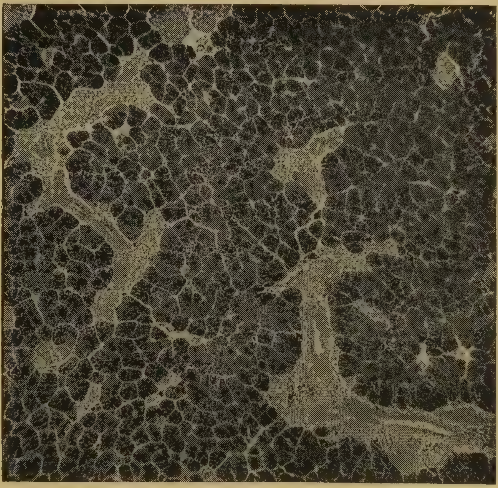
But here we must proclaim a new stage in the history of surgery, a stage in which the very discoveries that made it possible will supersede it in large degree. Let us take, for instance, what is usually called "surgical tuberculosis". A child has a "white swelling" of the knee-joint, which yields to no remedies. Later, he suffers from starting-pains at night, and serious lameness. After injections of iodoform and other remedies have been tried, antiseptic surgery is called in. The surgeon exposes the knee-joint and removes it bodily. He apposes the thigh-bone and the shin-bone, each with a perfectly healthy raw surface, the disease having been completely removed, and they soon unite, giving the patient a single shaft of healthy bone from hip to ankle. This is a remarkable achievement, which has saved scores of thousands of legs in the past twenty-five years or so, and is evidently much to be preferred to the cleanest amputation.

But what of the two chapters in which we discussed the struggle for life between man and the tubercle bacillus? Clearly this is a case where we want something better than the best surgery — or perhaps we want something which corresponds to that latest development of surgery, which we call aseptic. The principle of that method is to prevent microbes from ever reaching the tissues of our patient. Let us apply this principle to the care of our children, to the milk they drink, to the food they consume, to their surroundings, — the nursery, the home, the school and the playground — and there will be no more tuberculous knees for the surgeon to cut out.

"Surgical tuberculosis" must be responsible for thousands of deaths annually, to say nothing of the pain, the deformity, the inefficiency and the expense which it causes. Good surgery can do and does great things here; but the wards and out-

that the continued administration of this preparation of the pancreas may compensate for the lost activity of these cells, just as in the case of the thyroid gland. Other observers in this country, in England and in Germany, have found reason to hope that the use of the active principles of this same organ may some day enable us to conquer malignant growths, with which they seem to have some connection, according to the German chemists in especial.

So much for this line of progress, along which the medicine of the future will surely have much to add to our single established achievement with thyroid extract. Now let us look at the magnificent work that has been done upon the lines which Pasteur initiated. We may conveniently deal with the special studies of the two most illustrious pupils of the French master, Lord Lister and Robert Koch. Those two represented the first generation of Pasteur's spiritual descendants. The first applied the sheer discovery of his master in one field. The second amplified the discovery by adding to the known parasites of disease; above all, by his discovery of the tubercle bacillus. The men of the next epoch, Professor Elie Metchnikoff and Professor Paul Ehrlich, have neither of them discovered the microbe of any disease. In a sense, their work lies deeper, though that work must, of course, come first. For, indeed, our science has really only just begun when it seems to culminate in the discovery of, say, the tubercle bacillus.



"THE ISLANDS OF LANGERHANS"

A section of the pancreas magnified 40 times. The darker sections represent tissue which secretes pancreatic juice. The lighter colored, irregular patches are areas of islet tissue secreting insulin.

Such a discovery closes a long chapter; but it opens a new one, just like the discovery of radium and radioactivity, or that of gravitation, or that of organic evolution, or Mendel's law. Plainly, we have now to ask why and how the parasite hurts

Photo by Mr. Lyonde, Toronto

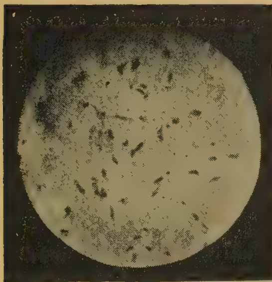
DR. F. G. BANTING

The discoverer of insulin.

Photo by Mr. Lyonde, Toronto

C. H. BEST, M.A.

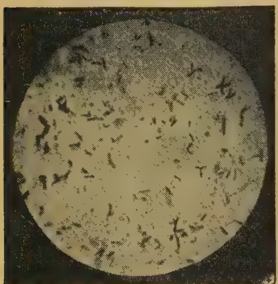
Dr. Banting's collaborator in the discovery of insulin.



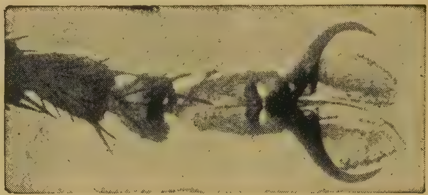
Bacilli of bubonic plague.

The rat-flea which carries the plague parasite.

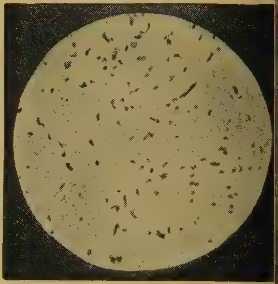
Cholera bacilli.



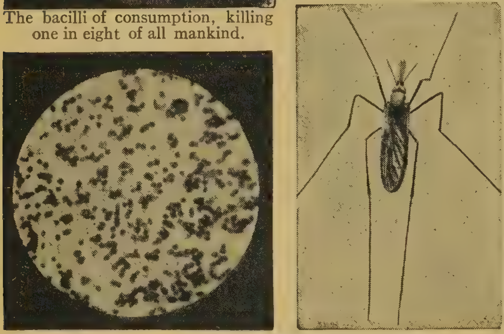
The bacilli of consumption, killing one in eight of all mankind.



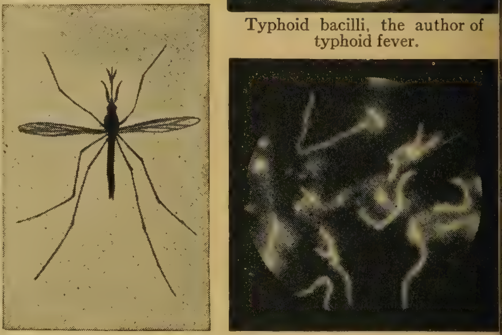
Leg of common fly, which carries disease germs.



Typhoid bacilli, the author of typhoid fever.



The malaria parasite and the mosquito which carries it.



The yellow fever mosquito and the parasite which it carries.

SIX APPALLING ENEMIES OF THE HUMAN RACE — DESTROYERS OF MILLIONS OF LIVES

Plainly, it depends upon powers of resistance; and if we are to distinguish between the man who inhales tubercle bacilli and kills them, and the man who inhales them to be killed by them; between men who catch a disease and men who, similarly exposed, do not; and between men who, having caught a disease, respectively conquer or are conquered — plainly, we must reach some very deep and real meaning of the word "health," and a meaning which applies to the daily exigencies of life as much as the capacity to digest food. It is just as important for health to digest one's microbes as to digest one's meals; and though the parallel is happy, it is also accurate, for vital resistance, and consequent health, mainly depend upon the production of ferments which digest and destroy invading microbes.

Since these new conceptions were finally established, with all that they involve fo the health of present and future gener ations, we have gone further still, and have tracked down the very elements of ou health in some degree. Metchnikoff ha shown that the white cells of our blood are among the chief agents of our health their daily and nightly duty being to search out and arrest and kill forthwith all manner of invading microbes. Metchnikoff therefore calls these white cells the "phagocytes," or "eating cells"; and poor fun, soon ended forever, is their owner's eating unless they do theirs well.

The facts of health in its most important aspect can be actually seen under the microscope, or upon the screen of a cinematograph. The healthy man, having gone abroad and incautiously exposed

THE SMILING EARTH GIVES UP HER RICHES TO MANKIND

"THE HARVEST OF THE EARTH AND THE GATHERING OF THE FRUITS THEREOF." From a painting specially made for The Book of Popular Science by Stephen Reid

Plant Life

THIS department by members of the faculty of the New York State College of Agriculture, tells about modern methods of crop and plant culture, about trees and fruits, vegetables and flowers, and what the wizards of science have done and are doing in experimental stations, on the farm and in the garden. Its illustrations alone teach a practical lesson only available elsewhere in an entire library on the myriad subjects involved.

Plants as Storehouses

Where plant-food is accumulated

How plants by garnering rich foodstuffs for their own progeny, feed mankind

The question of the annual, biennial and perennial habit of life among plants closely connected with nutrition storage

Growth of Root and Stem

The thrust of life towards food

The several forms and adaptations of roots and stems—climbing, twining and woody—all developments of the primary root

The difference between primary and secondary roots and between tap, tuberous, fibrous and adventitious

A Plant's Life-Processes

How a plant feeds and breathes

Buds and leaves, their structure, development, action and uses

How the leaf can manufacture starch when the chemist is unable to do so

A Plant's Fight for Life

The external relations of plants

Some of the special arrangements by which accommodation to changing conditions is secured

Plants that flourish in the shade or grow in darkness, that die when exposed to full sunlight

Intelligence in Plants

Plants that catch and eat insects

Movements of roots; leaves and other organs, purposeful actions that might be described as intelligent

Sensitive plants that a breath affects, flowers that close at night or when it rains

The Defenses of Plants

The struggle with the animal world

How plants that live near the ground ward off their enemies with poison, dagger and subterfuge

Plants that attract, catch and eat insects much as a spider would do

How Plants are Spread

Unconscious servants of plants

How stationary growths prevent overcrowding by dispatching their seeds to a distance

How they ride on the backs of unconscious animal mounts, and wing their way on gossamer gliders

Fruit and Seed Dispersal

Travels of a seed by land and sea

Plants that eject their seeds or fruit considerable distances, like a pea, from a popgun

The plant's growth so arranged that when the fruit is slung no other structure is in the way

Plants and their Partners

Mutual services by plant and animal

Attractions offered by flowers to bird and insect to induce their visits

Hospital door-steps and guide lines to aid the answerers to color advertisements

Some Enemies of Plant Life

Diseases which these organisms cause

Parasitic fungi, bacteria, slime molds, algæ and flowering plants

Rusts and smuts that attack plants and what happens when late blight strikes the potato crop

Common Diseases of Garden Plants

Methods of prevention and eradication

Common maladies of the potato, tomato, bean, beet, lettuce, cabbage and onion

What the disfigurement as well as the actual harm costs the unfortunate gardener

Insect Enemies of Fruit Crops

Most approved methods of defense

Attacks upon the apple, pear, plum, cherry, peach, grape and raspberry

Spraying for the codling moth, dusting for the Mexican boll-weevil, checking other pests

Functions of the Flower

The endless marvels of adaptation

Structure and component parts of the flower and their relation in continuing the life of the species

The varying forms of pollen grains ready to be carried to the stigmas of the female flowers

The Fruit of Plants

The increased popularity of fruits

The several characteristics, repellent and attractive, that fruits assume to perpetuate their species

How fruits are defended against birds until the seeds are ripe for dispersal

Trees as a Spectacle

The secret of autumnal coloring

Every tree has its own special characteristic features and appearance as much as a human being

Relationship between arrangements of branches and leaves and between shape of leaf and that of the tree

The Community of Trees

Arboreal strife for light and life

Wasteful and unscientific logging, and cutting in accordance with forestry methods

Moths, grubs and animals that are a menace to forest and shade trees

The Trees of the Forest

How they resist the wintry storm

The forests of America, their geographical disposition, characteristics, needs and best composition

The natural devices by which trees resist strain by the wind

The Plants of the Sea

Vegetable life in Neptune's garden

The sea plants' coloring and susceptibility to depth, temperature and saltiness

Why aquatic plants, when brought to surface, quickly collapse and lose their shape and beauty

WHAT THE SOIL IS MADE OF

The Composition of the Earth beneath Our Feet and Its Part in the Support of Plant Life

THE THINGS THAT MAKE THE EARTH FERTILE

MOST people consider the soil as an inert mass, having little or no relationship to plants except as a convenient means of mechanical support. They little realize how much the soil contributes to plant growth and that without the specific attributes and properties possessed by the soil no crop could be grown at all. Until recently few understood the chief causes of fertility and how productivity might be most economically increased. A clod of earth has so long been considered as a lifeless thing that the term is almost proverbial.

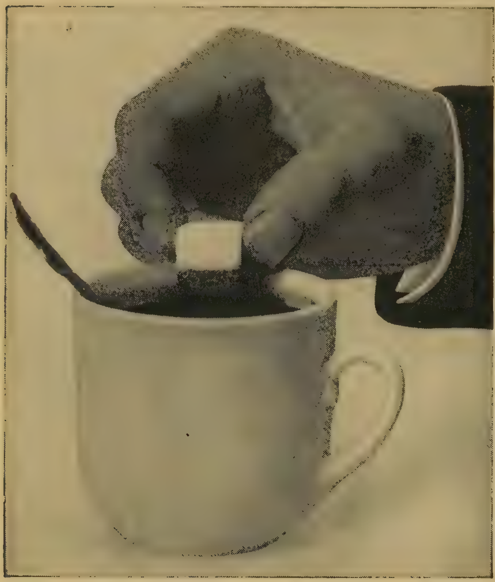
As a matter of fact the soil is not lifeless but is teeming with many forms of living matter. To be sure, the life forms are very minute, but this is made up for by their immense numbers. The individuals representing life underfoot exceed many, many times those above ground. They make up a world of their own, which rivals ours in wonder and importance. Most common of the forms are the soil bacteria or germs, which are present to the number of many hundreds of millions in every pound of normal soil. These germs influence the materials out of which the soil is formed and by

From Yeaw's *Market Gardening*, John Wiley and Son

A SUCCESSFUL GARDEN

The production of abundant crops is both an art and a science upon which the future of mankind depends.

HOW MULCH PRESERVES MOISTURE



From *Soil Sense*, The Dunham Co.

COFFEE RISING THROUGH SUGAR

COFFEE DOES NOT RISE THROUGH LOOSE SUGAR

A demonstration of the principles that make a soil mulch effective. Coffee rises rapidly through the compact lump sugar but moves but slowly into the loose layer placed on top.

From S. W. Fletcher's *Soils*, Doubleday, Page & Co.

MULCH

Under the dry soil mulch is found the moist layers bearing abundant available moisture.

PROPAGATION OF PLANTS

Artificial Reproduction by Cutting, Layering, Budding and Grafting, and the Problems of Hybridization

WHERE PLANT AND ANIMAL GROWTH DIFFER

We have been considering to what an extraordinary extent it is possible for man to interfere in the normal life of plants and trees for purposes of his own in the direction of producing trees of various sizes and shapes, and fruits of special quality. We have referred to the methods by which these processes are carried out as the "surgery" of plants; and we have already pointed out that the plant surgeon actually goes so far as to create species of a type which he himself has mentally conceived. This he does by the process of hybridizing. But there are yet other possibilities of plant surgery to be considered.

It will be recognized, of course, that all these processes, directed to the production of special types of plants, depend really upon the phenomenon of reproduction in plants; and it may be well here to emphasize that this physiological function of reproduction, by means of which plants have the power of producing new individuals, occurs in two distinct ways in the vegetable kingdom.

We have, for example, reproduction by sexual methods in plants just as in animals, methods which are known as "fertilization," and concerning which we shall have a good deal to say later. At the same time, reproduction in plants may be carried out by what is termed the "vegetative" method, and it is to this process that we are at present directing our attention.

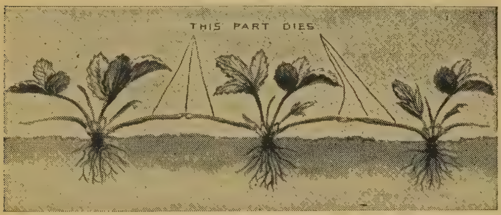
Vegetative reproduction in plants is a phenomenon which may be seen in quite a number of different phases, and it may occur either naturally or by artificial interference on the part of man.

An example of natural vegetative reproduction and multiplication is seen in the potato, in which the underground roots, which proceed from the parent plant, grow into thickened and swollen portions at their extremities — the potato or tuber. In ordinary agriculture this is dug up for food; but if it be left in the ground when the stem dies down, every tuber or potato in the following year will, by the process of vegetative reproduction, spring up as a new plant. This is quite a common process with plants having underground roots.

Another instance of this process of reproduction is that seen in the strawberry. A strawberry plant, left to itself, produces a number of "runners," which spread over the ground in various directions from the central plant and take root at intervals. From each node at which the runner takes root a growth of a new individual plant arises, and the separation occurs by gradual decay of the tissue of the runner. Many similar instances of vegetative reproduction are seen among bulbous plants.

It was doubtless originally from the observation of this natural process that the primitive gardener conceived the idea of imitating it artificially. If plants could give rise to new individuals by rooting little pieces of themselves in this way, why should not man take such portions of plants as he wished and make new individuals from these? True, it is a somewhat extraordinary thought that a small portion of a plant cut off from its parent stem and placed in the ground should have the power of producing a complete individual with all its parts, but it is, nevertheless, true.

This is one of the marvels of plant life as distinct from that of the life of higher animals. It is a fact that a piece of a root, a portion of a stem, or — still more wonderful — even a portion of a leaf of some plants, separated from the parent growth and put into an environment which offers suitable nutrition and protection, are actually capable of producing roots for themselves and ultimately complete individual plants having all the characters of the parent plant from which they were taken. This primitive discovery, probably made when man carelessly stuck a stick into the ground and left it there, and which was afterwards found to have taken root, doubtless led very soon to the method of propagation of plants by means of cuttings. Observation of other plants would lead to artificial reproduction by means of layers as well as cuttings, and these in time to the more elaborate procedure of budding and grafting.



VEGETATIVE REPRODUCTION — SELF-LAYERING STRAWBERRY RUNNERS

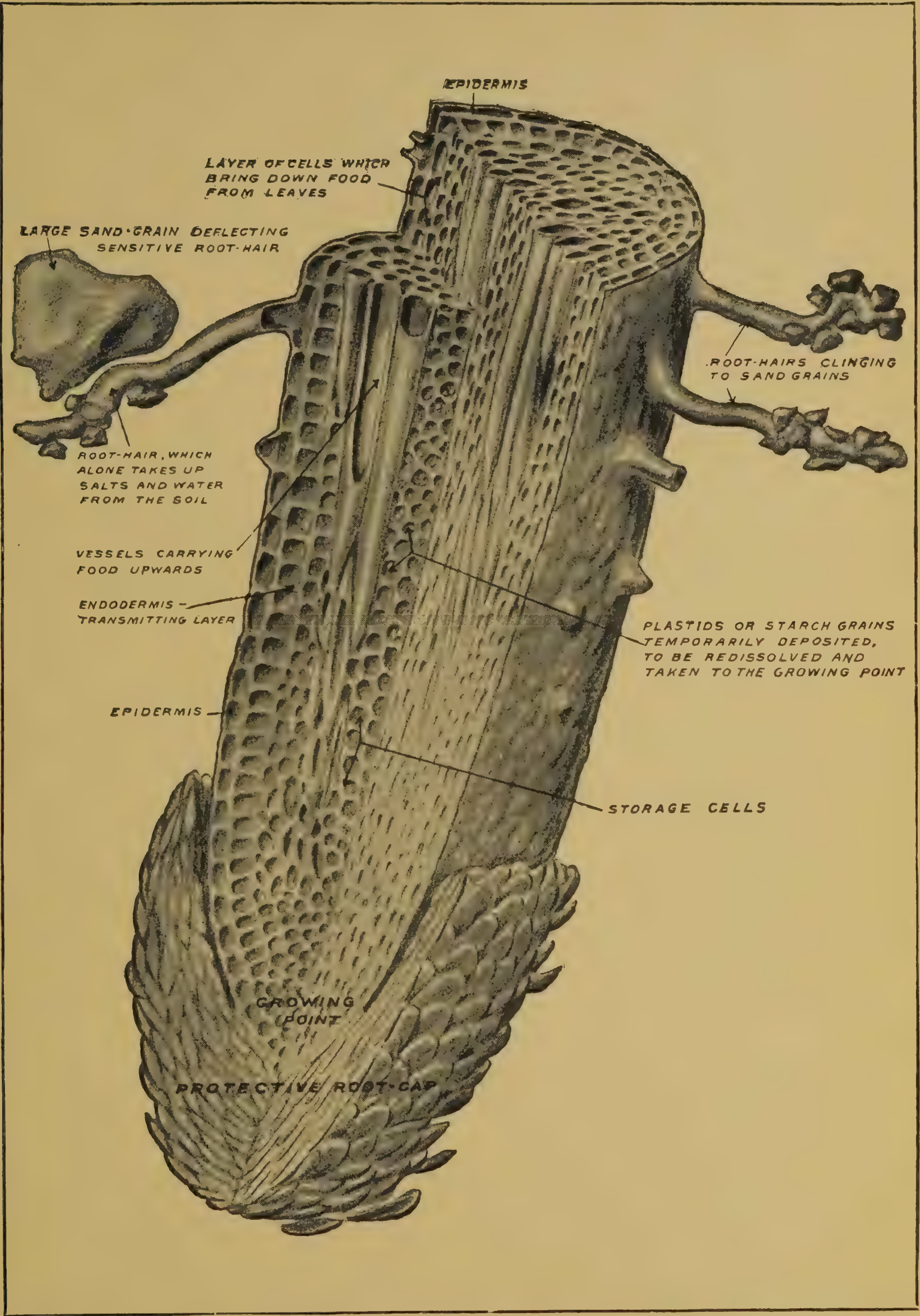
VEGETATIVE REPRODUCTION BELOW THE SOIL
The lily-of-the-valley differs from the strawberry by developing its branches underground, as here shown.

In the process of vegetative reproduction from cuttings, any portion of the plant, be it leaf, branch or root, may be used. The greatest development of roots, however, always results when the end of the cutting nearest to the earth in the parent plant is the part that is planted.

As examples of plants which may be propagated from root cuttings we may mention pelargoniums, while an example of propagation from leaf cuttings is to be found in the well-known begonia. In the latter case it is only necessary to place the leaf, or a portion of it, on moist soil in a suitable temperature, and nature will do the rest. It is more common, however, to select young shoots for propagation by cuttings; and these are cut off just below a node, as it is at this point that the new roots appear. Many of our domestic plants are readily and easily propagated by this method, among the most notable, perhaps, being currants and gooseberries. The cutting is usually from eight to ten inches in length, and is taken from the parent plant at the end of a season's growth, when the leaves have fallen off. The buds on the cutting are rubbed off where it is to be inserted under the ground.

Vegetative reproduction by means of layers is done by fixing a portion of a young shoot into the earth by an artificial pin of some kind. The shoot is simply bent down and forced underground to such an extent that it is well covered. In due time the underground portion gives off roots; and when that has happened the bent portion above the level of the soil may be divided with a knife, thus severing any connection with the parent plant. Imperfect division of the portion bent underground is also practised to prevent the flow of sap back from the free portion of the shoot. This helps in the formation of new roots. Naturally, it is easier to start a new plant by means of layering than it is by cuttings, because in the layering process the connection between the old plant and the one that is to be produced can be maintained as long as necessary. As a matter of fact, this process is largely used when it is wanted to grow apple, pear and other fruit stocks quickly, these being used afterwards in the further process of grafting and budding.

Budding and grafting may be regarded as being operations which demand the greatest skill and judgment, both in selection of the tissue to be used and in the technique of the procedure itself.



This picture-diagram shows a root in section, with the various structures named. The cells in the root hairs absorb the moisture from the soil by the process of osmosis, and also secrete carbonic acid, while the cells within the root act as conductors for carrying the food through the plant and for storage.

HOW TO IMPROVE THE APPLE HARVEST

A 13-year-old apple-tree injured by leaving fillers in the orchard too long, characterized by long upright branches.

A high-headed tree. If such trees are renovated they should be severely headed in, as indicated in the picture by the curved white line.

A well-shaped tree. This tree was grown in an orchard without fillers. It should be compared with the first in this row.

Long-armed trees. The result of close planting. Half the trees should be removed and the remainder headed in, as marked.

The first year's growth after the renovation of some old, high-headed trees. The proper treatment for the trees shown on the left.

The left-hand picture shows a high-headed tree badly in need of repair; in the right-hand picture the same tree is shown after it has been pruned, but it needed much more drastic treatment, and should really have had the top removed down to the white mark.

A good type of apple-tree for renovation.

The same tree after it has been accurately pruned.

THE RIGHT AND THE WRONG METHODS OF IMPROVING THE YIELD OF APPLE-TREES

A MENACE TO FOREST AND SHADE TREES

Courtesy State of New York Department of Farms & Markets

THE GYPSY MOTH (*Porthetria dispar*, Linn.)

Different stages from egg cluster to adult of the gypsy moth. The figures are all natural color and size except No. 2.

1. Female and egg mass on the trunk of a tree.
2. Eggs (magnified to twice their natural size).
3. Full-grown caterpillar.
4. Pupa.
5. Female moth.
6. Male moth.

INSECT ENEMIES OF FRUIT CROPS

Attacks upon the Apple, Pear, Plum, Cherry, Peach, Grape and Raspberry

MOST APPROVED METHODS OF DEFENSE

NO account of the enemies of plants would be at all satisfactory which did not include a discussion of the various kinds of insect pests that infest our orchards and attack our different varieties of fruits. There are many kinds of these pests that injure fruits and they cause very great losses each year. It is no uncommon thing to find the crop of a certain kind of fruit almost ruined as the result of an attack of some insect, and there is scarcely an orchard or garden in this country that does not suffer more or less injury every year from some one or more of these pests. It has been estimated that the various insect pests in this country which attack the deciduous fruits, such as the apple, pear, plum and the like, cause an annual loss of over $66,000,000. It is impossible to discuss each of the insects that are responsible for this great amount of damage, and we shall have to be content with an account of the life history and habits of a few of the better known and more injurious ones, together with a consideration of the most approved methods of preventing their ravages.

One of the oldest, best known and at the same time most destructive apple pests is the codling moth, which also attacks the pear and quince. An authority on this insect estimates that it causes a loss of over $16,000,000 each year to the fruit growers of this country, to say nothing of its ravages in Europe and other apple-producing countries where it is also found.

The moth is a small gray one, measuring only about $\frac{3}{4}$ of an inch in width when its wings are fully expanded, as shown in Figure 1 on the next page. The moths appear in the spring about the time or very soon after the apples blossom, and in a few days begin to lay their tiny white eggs on the leaves, branches and later on the young apples. In a week to ten days the eggs hatch, and the small caterpillars find their way to the young apples, which they enter mostly through the blossom ends. The caterpillar lives within the apple for about one month and burrows through the pulp of the fruit, eating the seeds and causing the apple to fall, or if it remains on the tree, greatly injuring it by the cavities eaten out of the inside (Fig. 2). When the caterpillar has become full grown, it is pinkish white in color and about $\frac{3}{4}$ of an inch in length. About this time the caterpillar makes a burrow to the exterior of the apple and when full grown leaves the fruit and crawls down the trunk of the tree, where it hides beneath a loose piece of bark, spins a cocoon, and either changes to a quiet object called a pupa, or simply rests in its retreat without any change until the following spring. Those caterpillars that spin cocoons and change to pupæ remain in this condition about ten days and then transform to the handsome gray moths that deposit their tiny eggs for a second generation of caterpillars or "worms", as they are usually called. In some parts of this country where the seasons are warm and long there are three or four generations of the codling moth each year. The caterpillars of the last generation pass the winter in their snug retreats and transform to pupæ at the advent of warm weather, and in three or four weeks the pupæ transform to the moths, thus completing the yearly life cycle.

The codling moth has many natural enemies that aid greatly in holding it in check. The eggs and the caterpillars are destroyed by tiny parasites, at least seven having been found to attack the caterpillars. If it were not for parasitic insects, our orchards and gardens would be literally destroyed in spite of all we could do. In addition to the work of the parasites, the caterpillars and pupæ of the codling moth are destroyed in great numbers by different kinds of birds. In fact, there are over a dozen birds that are known to feed on this pest, and they constitute the most effective natural enemies of the codling moth. The nuthatches, chickadees and downy woodpeckers search out the caterpillars in their hiding places beneath loose pieces of bark and devour them. These birds are so efficient in controlling the codling moth that special pains ought to be taken to attract them to our orchards. Pieces of suet tied to the branches will attract the birds and induce them to remain and nest among the trees. But in spite of all these natural enemies, the codling moth is the most destructive insect enemy of apples, and the severity of its injuries and the great losses caused by it emphasize the necessity of taking effective methods of artificial control.

FIG. I. CODLING MOTH
(enlarged three times)

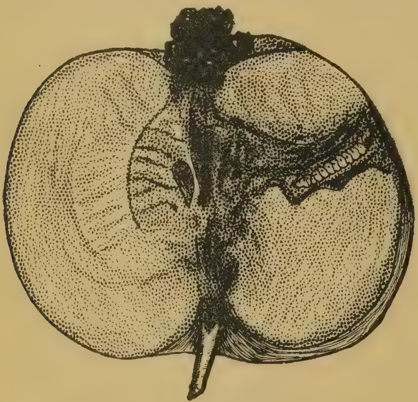


FIG. 2. A "WORMY APPLE"
Caused by the larva of the codling moth.

Fortunately, an effective method has been found for the control of the codling moth. In this country nearly every progressive apple grower sprays his orchard at least twice every season and by so doing protects his crop of apples from becoming wormy and unfit for market. As soon as three-fourths or all of the blossoms have fallen the trees are sprayed with paste arsenate of lead at the rate of 5 pounds to 100 gallons of water. The young apples are just forming, and at this time they stand upright (Fig. 3) with the small brown leaves called the calyx at the blossom end spread wide open. Great care is taken at this time to put the spray mixture into the blossom end of the apple down in what is called the calyx cup, for it is here that the tiny caterpillar enters the apple and takes its first meal. In a few days the calyx cup closes tightly and it is too late to spray, but if the poison mixture has been sprayed into the open cup, it will remain there a long time awaiting, as it were, the coming of the tiny "worm". This is the most important spraying for the codling moth and should be done thoroughly and with great care. Since some of the caterpillars enter through the sides of the apples and therefore do not eat the poison placed in the blossom end, a second application of the poison is recommended about three weeks after the first one. Finally, many apple growers often make a third application in mid-summer to poison the caterpillars of the second brood.

Formerly, burlap bands were put around the trunks of apple trees to form places beneath which the caterpillars would crawl to spin their cocoons. By examining the bands now and then and crushing the caterpillars found beneath them many were destroyed. It is now known, however, that spraying is much more effective in killing the caterpillars, and burlap bands are seldom used.

THE WONDER PACKED IN A TINY SEED

One of the mysteries that no man can explain is the way in which a tiny seed grows in a few months to be a beautiful flowering plant, eventually dying and providing more seed for the perpetuation of the species. At the foot of this page (from left to right) are shown the actual seeds of the scabious, the canterbury bell, the sweet-pea, the begonia, the gaillardia, the sweet-william, and the antirrhinum, and above them are the lovely blossoms that form out of these seeds.

DISEASES OF GARDEN PLANTS

Common Maladies of the Potato, Tomato, Bean, Beet, Lettuce, Cabbage and Onion

METHODS OF PREVENTION AND ERADICATION

PRACTICALLY every wild and cultivated plant is injured to a greater or less degree by one or more parasitic organisms. The diseases which result are, however, in some cases of so little importance that the vigor of the plant is not impaired. Cultivated crops are usually diseased to some extent, but often the resulting financial loss is insufficient to warrant the expenditure of time and money for its prevention. In other cases the same or a different disease may involve the total loss of the crop. Weather conditions play an important part in determining the seriousness of plant diseases. Rainy periods are usually followed by destructive outbreaks of certain maladies, due to the fact that the presence of abundant moisture favors the rapid development of the parasite. In one season, for this reason, a given disease may be very destructive, while in the next practically no trace of it may be found. One week a field or garden may present a healthy appearance, and the next week half the plants may be ruined. A large element of chance enters, therefore, into the raising of most plants. The wide-awake, modern grower may, however, insure himself against serious loss by using standard methods of prevention.

Few plant diseases caused by fungi or other microörganisms can be cured after the plant has actually become affected. The entrance of the parasite into the interior of the plant can, however, usually be prevented. Fungicides are used primarily to prevent injury rather than to cure that which has already taken place. In this respect the treatment of plant diseases differs radically from that in vogue in the treatment of disease in man. In reality the fungicide serves as a protecting armor to the plant; but in most cases after the fungus has gained an entrance it is then too late and absolutely useless to apply the fungicide. In a few cases, in which the fungus is normally largely external on the host, such as the powdery mildews of roses, hops, lilacs, cherries and other plants, dusting the affected portions with sulphur will kill the organism and restore the host to health.

Not all methods of disease control have to do with the application of fungicides. Pruning out of affected parts, various types of seed treatment, soil sterilization, crop rotation, the application of various substances to the soil, drainage, the complete eradication of alternating host plants, the destruction of insects carrying the disease germs, the planting of immune or resistant varieties of host plants, and exclusion of diseased plants from a given territory by federal or state inspection or quarantine constitute some of the other remedies.

The implements for combating plant disease should be always on hand and in condition for use, and the application of a spray on short notice should be possible. No grower who hopes to obtain clean crops should trust to chance. He should have always available the means for fighting the many fungi and bacterial foes which are sure sooner or later to assail his plants. In the use of spray mixtures the owner of a small garden will find

COMMON DISEASES OF GARDEN PLANTS

Raspberry canes, showing large excrescences caused by the "crown gall" organism, *Bacterium tumefaciens.*

"Anthracnose" of beans. Pods showing prominent lesions due to the presence of the anthracnose fungus, *Colletotrichum Lindermuthianum.*

A lettuce leaf showing prominent disease spots caused by *Marssonina Panattoniana.*

"Club root" of cabbage. A young plant with the roots diseased and hypertrophied due to the attack of *Plasmodiophora Brassicæ,* a slime mold.

RUSTS AND SMUTS THAT BLIGHT PLANTS

The white pine blister rust, showing the typical pustules of rust spores.

Wheat smut. The head of grain to the left is normal, the others badly smutted. The causal organism is *Ustilago tritici*.

Oat smut. The causal organism is *Ustilago avenæ*.

Fire blight of apple due to *Bacillus amylovorus*. A badly blighted and blackened twig contrasted with a healthy one.

Fortunately, the woolly aphis is held in check by several enemies, among which are certain tiny parasites. The aphids are also devoured by the larvæ and adults of several species of ladybird beetles and by the larvæ of lace-wing flies and of certain true flies known as the "syrphus flies". Undoubtedly birds feed upon them and aid in holding them in check.

The aphids on the branches may be killed by spraying the tree thoroughly with a 15 per cent kerosene emulsion. This may be made by dissolving half a pound of soap in one gallon of water and adding two gallons of kerosene. While the water is quite hot the mixture should be thoroughly agitated until a white, creamy emulsion is formed. This stock solution should then be diluted with $10\frac{1}{3}$ gallons of water to form a 15 per cent emulsion.

FIG. 5. A PEAR BADLY INFESTED WITH THE SAN JOSÉ SCALE

The aphids underground are much harder to destroy. In the first place one should not accept trees from the nursery which are infested with the woolly aphis. Considerable experimental success has been had in this country by soaking the soil around infested trees with a 15 per cent kerosene emulsion. The soil is first removed around the tree over a circular area of $1\frac{1}{2}$ to 4 feet in diameter, depending on the size of the tree, and to a depth of 3 inches. The soil is then soaked with the emulsion, 3 gallons on the smaller area and 6 gallons on the larger, after which the earth is replaced.

The San José scale, which would better be called the Chinese scale because it originally came from China, is another very serious pest of the apple in America, and it has also become established in Japan, Australia, Chili and Hawaii. European countries have so far been able to keep it out of their territories by rigid quarantine. It not only attacks the apple but is a very serious pest to the pear, peach, plum, prune, apricot and currant (Fig. 5). In fact, it thrives upon a great variety of fruit trees, shrubs, shade and forest trees.

It was first discovered in this country near San José, Cal., where it was probably introduced about 1870 on imported plants. It was first known to science and first given a name in 1880. Since that time, however, it has spread into nearly every state in the United States and has reached many sections in Canada. The San José scale attacks all parts of the tree above ground, and when abundant kills the infested plants. On badly infested trees, especially peach trees, the branches become completely covered by the tiny insects and appear as though enveloped in a grayish incrustation. Each female insect has a long, slender beak which she forces through the outer bark into the tender, sappy layers beneath and sucks up the nourishment from the tree.

Each tiny insect is covered with a small waxy scale, which in the case of the female is circular and about the size of a pinhead (Fig. 6). The body of the female is yellowish, and she has no legs or wings and consequently cannot move about after once becoming established beneath her waxy house. The male, after a short time, develops an elongated scale and becomes furnished with wings with which it can fly. Curiously enough, the male insect has no mouth parts fitted for taking food and does not live long after it becomes full-grown.

SOME WINGED BEAUTIES

PAPILIO TELEGONUS ♂ AND ORNITHOPTERA BROOKEANA ♂

NECYRIA MANCO ♂ AND ANCYLURIS MELIBAEUS ♂ UNDERSIDE

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may have served a purpose as a scavenger; but as now it flits from its noxious feast straight to the food that he eats, and the milk that he and his children drink, the following figures, published by Dr. L. O. Howard, in his impressive volume on the subject, assume a specially sinister aspect.

Beginning on April 15 with an overwintering fly, which on that date laid 120 eggs, he arrives at the following table, postulating that all eggs and all individual flies survive, and allowing ten days to a generation in summer.

April 15: The female lays 120 eggs.

May 1: 120 adults issue, of which 60 are females.

May 10: 60 females each lay 120 eggs.

May 28: 7200 adults issue, of which 3600 are females.

THE COCKCHAFER IN FLIGHT

June 8: 3600 females each lay 120 eggs.

June 20: 432,000 adults issue, of which 216,000 are females.

June 30: 216,000 females each lay 120 eggs.

The table continues in this manner on to September 10, when 5,598,720,000,000 adults issue, of which one half are females.

Of course, not nearly all the eggs or adults survive, but the table is illuminating as showing the terrible potentialities for increase possessed by a single fertilized female fly. There would be no lamentation on the score of extinction of a species should the last house-fly perish. A well-known public man, who is deeply concerned with the problem of child life in a busy northern city, lays it down as a business proposition that it pays that city better to provide the children of the poor with sterilized milk at the cost of the tax-payers than to meet the cost of funerals of poor children killed by fly-infected milk.

The habits of the gnats and mosquitoes have already been described, and need not be recapitulated, nor a word added to the tragic history of their death-dealing actions against man. Gnats and mosquitoes are one and the same, but midges, although allied to the others, are distinct. Although the hateful little black midge that bites at night rather gives the lie to the general statement, it is a fact that midges, taking the majority, do not bite, for the reason that they lack any blood-sucking apparatus. A curious thing has been observed of an Asian relative of the plumed midge (*Chironomous plumosus*).

THE GREAT GADFLY

Vast numbers of these insects frequenting the shores of Lake Issyk-kul were found to be brightly luminous. The light emitted was due to the presence in the insects of multitudes of parasitic bacteria, whose presence prevented their hosts from rising on the wing. There is another true midge, however, *Ceroplatus sesioides*, which is luminous from natural internal mechanism, as in the case of the glow-worm, but here the light proceeds from the whole body of the insect, and is given off by both sexes.

The gall-midges are quite another group, and, with the so-called Hessian fly at their head, do incalculable damage to crops when in the larval stage. In this group we find an extraordinary case of reproduction by the larvæ. The gall-midge in question is *Miastor metroloas*. During

THE ORGAN WITH WHICH THE BEE SUCKS

The proboscis or tongue of the honey bee—of which the end portion is shown here highly magnified—is a hollow organ filled with fluid and terminating in a "bouton" or spoon. The nectar gathered from a flower by the bouton passes up the flexible under surface of the tongue in a groove, which is surrounded by thickened skin and formed into a tube by numerous fine hairs. The nectar then enters the pharynx, and passes, mixed with saliva, into the honey-bag, where it is changed into honey.

The photographs on these pages are by Mr. J. J. Ward and Messrs. Hinkins and Son.

spider is simply a larger cousin of the big wolf-spider, and undoubtedly gives one a shrewd nip, which is followed by considerable pain, though not nearly so bad in effect as the sting of a scorpion. The tarantula has a shocking name. In the Middle Ages an epidemic suggesting St. Vitus' Dance spread over southern Europe, and, because it was attributed to the bite of this spider, it was named "tarantism". There has been a revival of it in Italy within the last few years, and distressing accounts were published not so very long ago. The disease really has no more to do with the tarantula than with the dodo, but is simply a nervous affection to which hysterical people are subject. In the old days music was declared to be the only cure, and a dance known as the "tarantella" is said to have originated from this treatment. Experiment has shown that the bite of the tarantula, though painful, and followed by local irritation, is neither fatal nor succeeded by any serious ill.

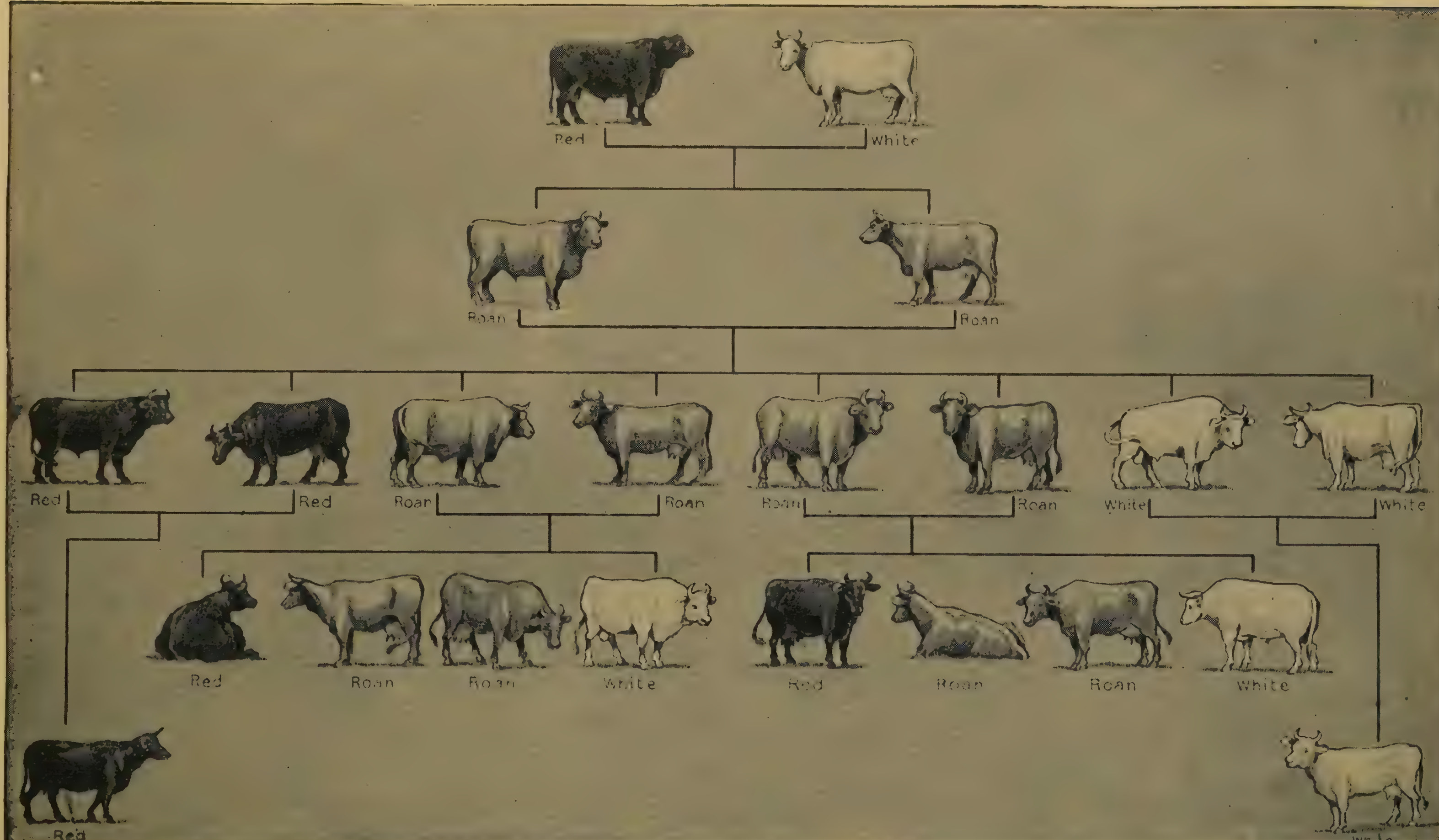
A FALSELY ACCUSED SPIDER — THE TARANTULA

The most loathsome of the spiders are the bird-eating examples (Aviculariidæ or Mygalidæ), happily restricted to tropical or sub-tropical climates. Little has been added to our knowledge of these animals since "Amazon" Bates wrote of them: "Many species of these monstrous hairy spiders, half a foot in expanse, which attract the attention so much in museums, are found in sandy places at Nazareth. The different kinds have most diversified habits. Some construct, among the tiles or thatch of houses, dens of closely woven web which, in texture, very much resemble fine muslin. These are often seen crawling over the walls of apartments. Others build similar nests in trees, and are known to attack birds. . . . At Cameta (equatorial Brazil) I chanced to verify a fact relating to their habits . . . worth recording. The species was *Mygale avicularia*, or one very closely allied to it. The individual was nearly two inches in length of body, but the legs expanded seven inches, and the entire body and legs were covered with coarse gray and reddish hairs. I was attracted by a movement of the great monster on a tree-trunk; it was close beneath a deep crevice in the tree, across which was stretched a dense white web. The lower part of the web was broken, and two small birds, finches, were entangled in the web. One of them was dead, and the other lay under the body of the spider, not quite dead, and was smeared with the filthy liquor or saliva exuded by the monster. I drove him away, but the second soon died."

The thickness of the Mygale's web is not without parallel. There are other tropical spiders which make webs stout enough to catch birds; and it is on record that one web contained a young mouse, which, ensnared as it ran along the ground, was girt about by separate threads of the spider and hauled four inches up into the web, where, after surviving for ten hours, it died. Snakes of small size, and a fish three inches in length, have been captured by the same means.

But for the wonders of web-making we need seek no farther than our own gardens,

A PICTURE-DIAGRAM OF MENDEL'S LAW AS EXEMPLIFIED IN THE COLORS OF CATTLE



If pure red and pure white cattle whose colors are of equal potency are bred together, the results shown in the above picture may be expected in the subsequent generations. The Mendelian explanation is that the roan hybrid carries from the beginning all the sex-cells which will decide the color, and carries them in a pure and not a blended condition, these cells being produced in approximately equal proportions.

Animal Life

FROM bird to beast, from insect to serpent, from fish to reptile, the extraordinary number and variety of animals that surround us all have one common trait and often only one—life. This is the subject of natural history, so called, and to its unfolding this department of our book is devoted. The curious, the extinct, the useful, the ornamental members of the animal kingdom are described and pictured as only those who *know* can present them. It is an astonishing procession that passes before our wondering eyes.

Rivals for the Mastery

What the first animals were like

The early days of the world when man and mastodon met in combat

What might have happened if man had never been created

Strange Things Like Men

The life-story of man's poor counterfeit

The curious, intelligent, terrible creatures which are so like and yet so unlike us

Travelers' tales about the gorilla now discredited

Evolution before our Eyes

Living creatures on the border line

The way animal life to-day helps to explain the changes in the past

Mammals whose young are born from eggs; a creature chiefly made of water with children unlike itself

The Animals of Terror

The fearful beasts that fear only man

Some members of the great cat family

Life and habits of lions, tigers, leopards, jaguars and cheetahs

Savages at our Gates

Wild life on civilization's borders

The life stories of hyenas, wolves, jackals, dingoes, foxes and wild dogs

Present day habits of the wolf shake one's credence in wolf-reared children

The Bear and his Cousins

The monarch of the frozen world

The polar bear one of the few animals not terrified by the scent of man

The great brown bears of Alaska the biggest bears now in existence

The Astonishing Giants

Survivals of the age of monsters

The life and characteristics of the elephant, rhinoceros, hippopotamus and giraffe

Why the latter runs so to neck

Some Animal Helpers of Man

Should more species be tamed?

Man's miracles of mastery of mind

Some of the animals he trained to do his work on the fringes of civilization

The Taming of the Wild

Can man extend his animal conquests?

The dog—the first wild animal that man succeeded in making a friend

"As dirty as a pig" a gross injustice to a naturally clean animal

The Insect-Eaters

Lowly benefactors of the world

Animals which maintain the balance of nature and preserve the food of man

The mole, that is giving up once good sight as quite unnecessary

The Wily Weasel Family

Why have we ceased to tame the wild?

A vermin-destroying family, valuable also for their furs

The evil-smelling skunk and the persecuted otter

The Deer Family

The mystery of the antlered herd

How the antlers originate, develop "in the velvet" and come to weigh as much as 70 pounds

The sadly dwindling numbers of the elk or moose

The Antelope Family

The link between goats and cattle

Animals inhabiting all uncultivated lands from jagged mountain tops to sandy plains

The 150 species run from pygmies no bigger than rabbits to giants bigger than a horse

Animal Home Builders

The master craftsmen of the world

The beaver, that intelligent constructor of elaborate engineering works

The arch no mystery to the natural engineer

The Gnawing Animals

The problem of animal destruction

Prolific mammals with which man is compelled to be constantly at war

Squirrels, rabbits, chinchillas and the greyhounds of rodents, hares

Animals in Armor Clad
The crocodile as a gruesome relic
Defensive survivals from the ages when jaw and claw ruled the Earth
Alligators of extraordinary age, deadly crocodiles and fretful porcupines

The Pouched Mammals
The fate of the monsters of the past
A low type of small-brained animals developed chiefly in Australia

Animal Friends and Foes
Enormous loss from prolific pests
The mouse, the rat, and the mungoose that destroys them

Mammals in the Water
How the legend of the mermaid arose
The strenuous life of land animals that have become monsters of the seas

Fin-Footed Carnivores
Blind extinction of animal races
Intelligent and affectionate creatures ruthlessly slain for their pelts

Birds as Man's Helpers
Our feathered allies in agriculture
What they do for us and how we can attract them about the house and garden

Our Common Birds I
Melodious thrushes and modest Jenny wrens
Robins, thrushes, chickadees, nuthatches, kinglets, creepers, wrens, nightingales and mockingbirds

Our Common Birds II
Woodland warblers and graceful swallows
The warblers, vireos and waxwings, shrikes and bank and barn swallows

Our Common Birds III
Dull flycatchers and gaudy tanagers
Kingbirds, peewees, phœbes, larks, crows and jays, starlings, blackbirds and orioles, meadowlarks and bobolinks, sparrows and finches

Our Common Birds IV
Gentle doves and crested kingfishers
No real difference between doves and pigeons

Our Common Birds V
The busy carpenters and weird nighthawks
Woodpeckers, swifts, whip-poor-wills, nighthawks and the humming-birds "glittering fragments of the rainbow," as Audubon calls them

Our Common Birds VI
The birds of prey
The beneficial and destructive hawks, the scavenging vultures, the soaring eagles and the malignant owls, feathered wisdom personified.

Our Common Birds VII
The Upland game birds
The wary grouse, vanishing turkey, friendly quail and gorgeous pheasants

Our Common Birds VIII
Water birds
Loons, grebes, gulls and terns, herons, swans, geese and ducks, rails, gallinules, coots, sandpipers and plovers

Bird Migration and Home Life
The bird on his travels and in his home
The long distances birds travel to seek congenial climate and food

The Maligned Snake Tribe
Masters of the world but for man
Inspirers of terror in man and beast but friends of agriculture

The Company of Lizards
Ugly but quaint, stolid but quick
Small-brained survivals from very early ages, the most harmless of the reptiles

Water-born Land Animals
Strange stories of lowly nurseries
The place of the frog, the toad, the salamander and the newt in the scale of life

Warriors of the Ocean
The teeming sea-life that feeds life
Sharks and dog-fish, rays, sword-fish, squids, octopuses and cuttle-fish

The Sea-Fish We Eat
Illimitable reserves of food for men
Cod, flounder, haddock, mackerel, bluefish, sea bass, shad, tarpon

Romance in the Rivers
Salmon, trout, sturgeon, pike and eels
Mysterious habits of the fresh-water fish we eat

A Final Survey of the Sea
Strange history of a pearl necklace
The curious life stories of some of the lesser folk of the ocean

Ants, Bees and Wasps
Some romances in earth and hive
The marvels of combination and organization in the insect world

Some Winged Beauties
The secret of the firefly's radiance
The butterfly's rainbow mantle and the dragon-fly's shimmering mail

From Worms to Insects
Strange chapters in natural history
Wonderful changes in a cycle of insect life

Insect against Insect
Organizing the battle of the flies
The vast importance to human prosperity of the most trifling things of Nature

SOME COMMON AMERICAN WATER BIRDS

OUR COMMON BIRDS I

Robins, Thrushes, Chickadees, Nuthatches, Kinglets, Creepers, Wrens, Nightingales and Mockingbirds

MELODIOUS THRUSHES AND MODEST JENNY WRENS

IN the noisy parks of the large cities, in the silent forests of the mountains, from the steaming lowlands of the equator to the rocky coasts of the Arctic, there is always a bird of the thrush family (*Turdidæ*) to welcome the traveler. In the cities it is the robin, the bluebird and the woodthrush; in the woodlands it is the veery, the hermit and the olive-backed species; in the tropics it is the solitaire and the "thrush-robin"; and in the Far North it is the wheatear. When we make the term "thrush" broad enough to include the ground thrushes, the accentors, the redstarts, the nightingales and the chats of the Old World, the family includes between five and six hundred species, but of these only about two hundred and forty are true thrushes. These are widely distributed throughout the world, but eighty of them are confined to the New World, of which only a dozen species are found north of Mexico.

As a family, the thrushes are medium-sized birds, usually under twelve inches in length, with strong wings and legs and with bills slightly notched near the tip and supplied with strong bristles at the base. They are uniformly colored rather than streaked, the majority brownish or grayish, although blues, yellows and even reds are found in the plumages of some. The underparts are white, or at least lighter than the backs, and in typical species are more or less spotted. In species having unspotted breasts, the young in their juvenal plumage show the spots that have been lost by the adults, as in the robin and the bluebird.

But it is not for the brilliancy of their plumage that the thrushes are noted; it is for the richness and beauty of their songs. The world over, some member of this family surpasses all others in the appeal which it makes to the human ear. In Europe it is the nightingale, in eastern United States it is the hermit thrush, and in the western it is the solitaire.

Except during the nesting season, the thrushes travel in scattered flocks, frequenting the borders of woodlands but coming into gardens if they can find food. During the spring and summer this consists almost entirely of insects, but during the late summer and fall the various wild fruits form an increasing percentage. Gardens having dogwoods and Virginia creeper are sure to attract the passing flocks of thrushes in late September or October, and in the South the mistletoe and holly sustain some species throughout the winter. The robin, the bluebird and the hermit thrush remain in southeastern United States for the winter, and the solitaire and the varied thrush in the southwest, but the veery, the olive-backed, the gray-cheeked and the woodthrush continue their journeys to Central America and northern South America.

Of all the thrushes, the robin is, of course, the best known, although in coloration it is so aberrant as not to be recognized as a thrush by many people. It was christened "robin" by the early settlers because of its general resemblance to the European robin, although the latter is a much smaller bird. It was probably originally a forest dweller, as it still is in some places, but like its European cousin, it has become accustomed to man and now builds its nest wherever it can find a sheltered ledge about the house.

ALLIES AGAINST AGRICULTURE'S FOES

BOBOLINK
With army worm for its young.

YELLOW-BILLED CUCKOO
With tent caterpillar for its young

DOWNY WOODPECKER AT WORK

A TREE SPARROW IS A WEED DESTROYER

RIVALS FOR THE MASTERY

The Early Days of the World When
Man and Mastodon Met in Combat

WHAT THE FIRST ANIMALS WERE LIKE

MAN is lord of the animal world, its highest consummation; but what if man had never been created? Would nature have then evolved the autocrat of the earth? How would she have fashioned him, how arrayed him? With what powers would she have invested him?

It is hard for the lay mind to conceive of a world without a man, though it was such a picture, indeed, that the earth presented until organic life had been millions of years established. We dimly realize that time and space have neither beginning nor end; and human life seems at first sight also to belong to the infinities. The idea of man's late beginning seems too unreal, perhaps, for our acceptance. The picture of man as semi-human, a beast warring with other beasts for bare existence, comes to our minds as preposterous and grotesque.

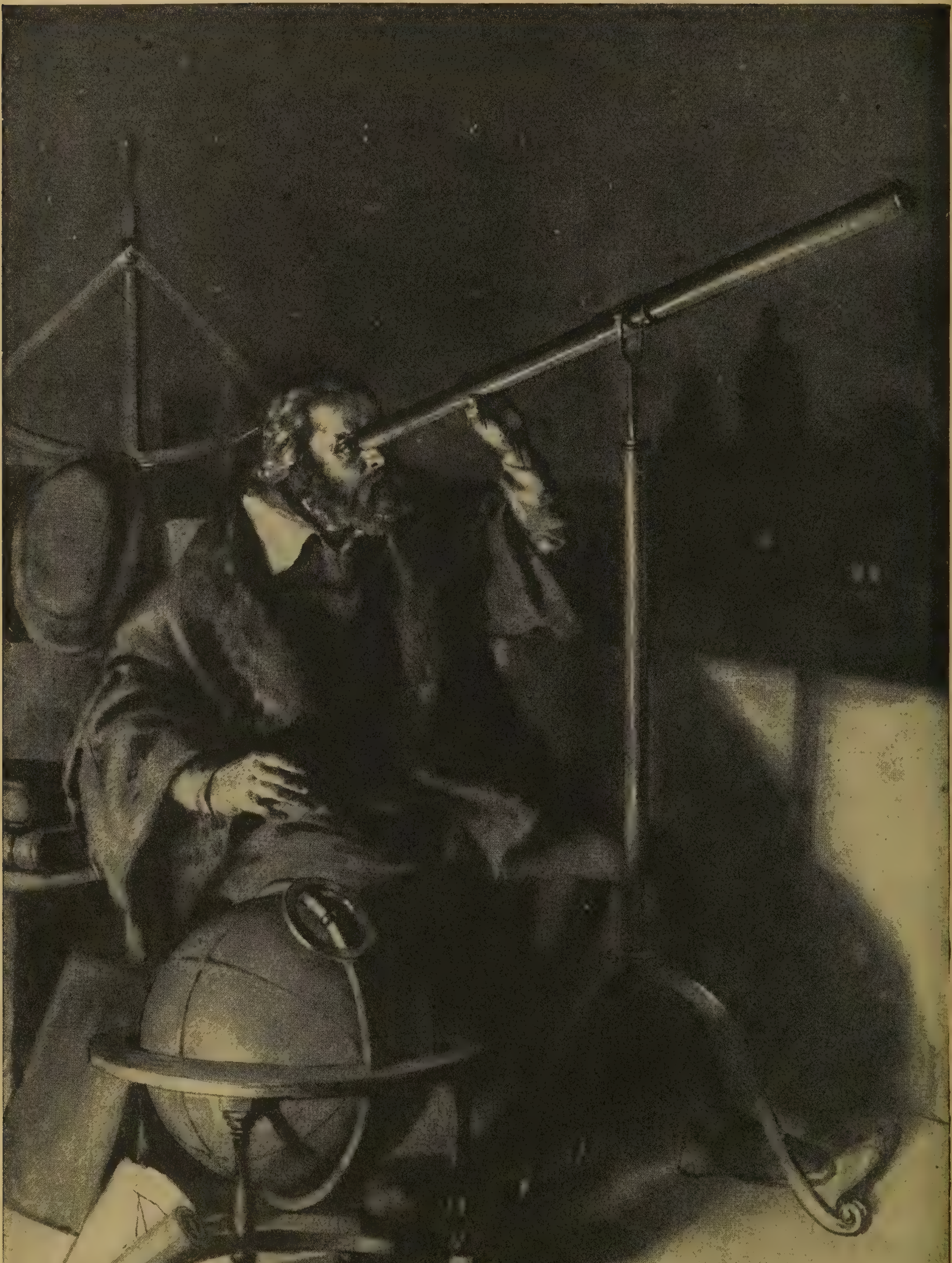
But the fact remains that man is a mammal, the most modern of the animals, and has come to his present stage of mental superiority comparatively recently. In his embryonic development, he still recapitulates in large measure the stages through which the life on the globe has passed. Beginning with the single egg and passing through stages that are comparable with the lowly forms of life that are still found in the sea, he passes rapidly over stages that represent millions of years in the development of life on the globe, until he is finally recognizable as a vertebrate and then a mammal. The great development of his thinking brain, however, finds no counterpart in the history of life on the earth and because of it, we must believe that he was given mastery of the world.

We need not attempt to catalogue the early stages of the story of organic life. The record is lamentably incomplete, though some of the early forms have left their records in the shape of cliffs and mountain ranges built up solely of their skeletons. Great cities flourish on foundations built up of the minute shells which sank in unnumbered millions to the bottom of oceans which have long since changed their beds. With the vertebrates came a scorpion, among the first of known land animals. It was a great day in the history of the world when he first crept out of the waters.

Then our record takes a flying leap and clears millions of years at a bound, for among the next notable finds revealed to us is the armored fish. We have as yet no record of the intervening forms which must have led up to this specialized animal, but here the story of evolution is first graphically impressed. The great battle for existence, for betterment, for conquest, had begun. The making of man was still far off in the ages of time, but the fight, beginning with the inception of life and continued ever since, was in full swing. The fishes had armed themselves; they had laid on plates of mail and cultivated formidable sharp-gripping teeth. "Eat or be eaten" was the law. And the scorpion, wearying of the conditions, had betaken himself with his sting to the land, though leaving his family abundantly represented in the waters.

In the same line of ascent with these creatures came the insects and spider-like animals. And here was another significant era in world-history. In the insects

GALILEO DISCOVERING NEW WORLDS



In the year 1609 Galileo made his first telescope at Padua, where he was professor of mathematics. He rapidly improved his instrument, and his discoveries in the year 1610 revolutionized all existing knowledge in astronomy. The discoveries of the satellites of Jupiter, the phases of Venus, the composition of the Milky Way, and the spots on the sun followed each other in quick succession.

Biography

IN previous outlines preceding the sample pages in this prospectus of the several great divisions of The Book of Popular Science, we have given the title of the various chapters and one or two of the topics treated in each, leaving the reader to consult the Index at the end of volume XV to see what a further array of information is actually included in all of them—far and away beyond the present limit of space to even mention. But now, in this interesting section of biography, to give an idea of the marvelous completeness of the work, we append an alphabetical list of all the men of science—astronomers, botanists, chemists, explorers, geologists, inventors, ornithologists, physicists, pioneers in thought and accomplishment—who, besides often frequent reference elsewhere in the 15 volumes, are accorded separate biographies, very many of them with portrait or other appropriate illustration. The treatment is popular but accurate, and shows that the work, in addition to so many other things, is a complete biographical dictionary of scientists ancient and modern.

Abēlard, Pierre
Synonym of the faithful lover

Abruzzi, Duke of the
The adventurous son of a king

Agassiz, Louis
The first naturalist of his time

Agricola, Georg
The father of mineralogy

Albertus Magnus
The *doctor universalis* of the Middle Ages

Alcuin
Founder of university education in Europe

Ampère, André Marie
And his unit of electrical measurement

Amundsen, Roald
Discoverer of the South Pole

Anaxagoras
Greek thinker who conceived the idea of God

Anaximander
First to discover why the Moon shines

Aquinas, St. Thomas
Greatest figure of medieval scholasticism

Arago, Dominique François
Who faced pirates to extend knowledge

Archelaus
Who denied that the Earth was flat

Archimedes
A great scientist before the time of Christ

Aristarchus
The man who found the Earth revolves

Aristotle
Master thinker of the ancient world

Arkwright, Sir Richard
Inventor of the cotton spinning frame

Arrhenius, Svante August
Great Swedish physical chemist

Audubon, John James
Best known of American ornithologists

Augustine, St.
The greatest of the Latin Fathers

Averroes
Celebrated Arabic philosopher

Babbage, Charles
Who made the first calculating machine

Bache, Alexander Dallas
Observer of tides, winds and magnetism

Bacon, Francis
"Wisest, brightest, meanest of mankind"

Bacon, Roger
The wonder man of the Middle Ages

Baffin, William
Polar seaman of Elizabethan times

Bailly, Jean Sylvain
Scientist of the French Revolution

Baily, Francis
Great reviser of star catalogues

Bain, Alexander
Modern exponent of a material mind

Baird, Spencer Fullerton
Organizer of the science of fish culture

Balboa, Vasco Nuñez de
The first man to cross America

Baldwin, James Mark
Social psychologist and genetic logician

Ball, Sir Robert
Famous popularizer of astronomy

Banks, Sir Joseph
A nature-traveler round the world

Barnard, Edward Emerson
Star photographer, discoverer of comets
Barnard, Henry
Nestor of American education
Bates, Henry Walter
The naturalist on the Amazon
Bayer, Johann
A man who made over 50 star maps
Beauperthuy, Louis Daniel
Pioneer in fighting tropical disease
Becquerel, Antoine César
Improver of the electric battery
Becquerel, Antoine Henri
Father of the new alchemy
Behring, Vitus
Discoverer of the passage between Asia and America
Bell, Alexander Graham
The inventor of the telephone
Bell, Sir Charles
Explorer of our nervous system
Bellamy, Edward
Dreamer of social reconstruction
Bentham, Jeremy
Hermit prophet of radicalism
Bergson, Henri
Whose philosophy depends on intuition
Berkeley, George
The bishop who shook the foundations of materialism
Berliner, Emile
Inventor of the gramophone
Bernard, Claude
Chemist explorer within the body
Berthelot, Marcellin
Founder of synthetic chemistry
Berthollet, Claude Louis
French chemist of arts and industries
Berzelius, Jöns Jakob
Discoverer of chemistry's facts and laws
Bessel, Friedrich Wilhelm
Father of observational astronomy
Bessemer, Sir Henry
Who began a new era in steel
Bichat, Marie François
Founder of the science of minute anatomy
Binet, Alfred
The measurer of mental age
Biot, Jean Baptiste
Student of the polarization of light
Black, Joseph
Founder of the real science of chemistry
Boerhaave, Hermann
A doctor who prescribed for all Europe
Boetius
Roman statesman, philosopher and poet
Bond, William Cranch
A watchmaker who watched comets
Booth, William
Founder of the Salvation Army
Bougainville, Louis Antoine de
First Frenchman to go round the world
Bowditch, Nathaniel
Distinguished navigator and astronomer
Boyle, Robert
Hero, thinker and inventor
Bradley, James
Discoverer of the aberration of light
Brahe, Tycho
Who would not believe the Earth revolves
Braille, Louis
Blind teacher of the blind
Brewster, Sir David
Inventor of the kaleidoscope
Broca, Paul
Brain student who explained speech centers
Brockway, Zebulon Reed
Successful reformer of criminals
Brunel, Isambard Kingdom
Great engineer on sea and land
Brunel, Sir Marc Isambard
Pioneer of tunneling under water
Bruno, Giordano
Who declared that God is everywhere
Buch, Leopold von
Champion of fire against water
Buffon, Count
Early popularizer of natural history
Bunsen, Robert Wilhelm von
Inventor of the burner that bears his name
Burbank, Luther
Gardener whose ways are Nature's ways
Cabot, John
Discoverer of the American mainland
Cabral, Pedro Alvares
Portuguese navigator, discoverer of Brazil
Campanella, Tommaso
Rejected dreamer of good government
Cannizzaro, Stanislao
Expounder of the molecular theory
Cardan, Jerome
Italian mathematician of the XVI century
Carlyle, Thomas
The thinker who made ideality real
Carnot, Nicolas Léonard Sadi
A founder of modern physics
Carrel, Alexis
Who has grown animal tissue
Cartier, Jacques
Explorer and colonizer of Canada
Cartwright, Edmund
Who revolutionized the cotton industry
Cassini, Giovanni
Who "wrote his name on Saturn"
Cauchy, Augustin Louis
Author of *Exercices de Mathématiques*
Cavendish, Henry
The first man to weigh the Earth
Celsius, Anders
Inventor of thermometer used by science
Chamberlin, Thomas Chrowder
Geologist, student of glaciers
Champlain, Samuel de
French explorer, founder of Quebec

Chapman, Frank Michler
Close-range student of bird-life

Chevreul, Michel Eugène
And the stearic acid candle industry

Clark, William
A leader of Lewis and Clark expedition

Clausius, Rudolf
Celebrated mathematical physicist

Clerke, Agnes Mary
A woman who made astronomy plain

Columbus, Christopher
The man who found the New World

Comenius, Johann Amos
The Moravian who made learning easy

Comte, Auguste
The founder of Positivism

Condillac, Etienne
Propounder of the theory that all knowledge comes through the senses

Cook, Captain James
The greatest navigator of his time

Cooper, Peter
Pioneer in education of the working classes

Cope, Edward Drinker
A great American paleontologist

Copernicus
Who rediscovered the Earth's rotation

Cortés, Hernando
An explorer at the point of the sword

Coues, Elliott
The locksmith of ornithology

Crafts, James Mason
Experimentalist in physics and chemistry

Crompton, Samuel
Inventor of the spinning-mule

Crookes, Sir William
Inventor of a wonderful tube

Curie, Marie
A woman who revolutionized science

Cuvier, Georges
The first student of fossil remains

Daguerre, Louis Jacques Mandé
Successful pioneer in photography

D'Alembert, Jean Le Rond
French mathematician and encyclopedist

Dalton, John
Schoolmaster, who made chemistry a science

Dana, James Dwight
Discoverer of chief cause of mountain structure

Darwin, Charles
The great pioneer of evolution

Darwin, Sir George
Student of tides and Earth's motion

Darwin, Erasmus
First poet of organic evolution

Davy, Sir Humphry
Who revolutionized the chemistry of his day

Dawson, Sir William
Canadian opponent of Darwinism

Delambre, Jean Baptiste Joseph
Author of the tables of Uranus

De Laval, Carl Gustav Patrik
Swedish inventor and engineer

Democritus
The first and greatest of the materialists

Descartes, René
The father of modern philosophy

Dewar, Sir James
Who liquefied hydrogen and solidified air

Dias, Bartholomeu
Discoverer of the Cape of Good Hope

Diesel, Rudolf
Inventor of a new oil engine

Dolland, John
And the story of the refracting telescope

Dolomieu, Gratet de
From whom the Dolomites are named

Drake, Sir Francis
Sea-rover of Elizabethan days

Dubois-Reymond, Emil Heinrich
Noted physiologist of the XIX century

Duns Scotus
English philosopher and theologian

Dutton, Clarence Edward
Soldier, geologist and seismologist

Eads, James Buchanan
Who cleared and bridged the Mississippi

Edison, Thomas Alva
The greatest inventor of all time

Ehrlich, Paul
Great inventor of curative poisons

Einstein, Albert
Expounder of a much-discussed theory

Elliot, Daniel Giraud
First naturalist in the Olympic Mountains

Empedocles
Scientific poet and philosopher

Encke, Johann Franz
Calculator of planetary orbits

Epictetus
The slave who believed in stoicism

Epicurus
Who taught wise pleasure is the end of life

Eratosthenes
Astronomer in the time of the Ptolemies

Ericcson, John
Maker of first workable screw-propeller

Eucken, Rudolf
Harmonizer of philosophy and religion

Euclid
Who taught us exactness in reasoning

Eudoxus
Bringer of astronomy from Egypt to Greece

Euler, Leonard
The Milton of geometry

Fabre, Jean Henri
The Homer of entomology

Fabricius, Johann
Student of Sun-spots

Fallopio, Gabriello
First to describe anatomy of the ear

Faraday, Michael
The founder of electrical science
Faye, Hervé Auguste
Discoverer of the Faye comet
Fechner, Gustav Theodor
Pioneer of experimental psychology
Fellenberg, Philip Emanuel von
Swiss agriculturalist and educator
Fermat, Pierre de
Founder of the modern theory of numbers
Fichte, Johann Gottlieb
Believer in mastery through education
Field, Cyrus West
The Columbus of modern times
Fischer, Emil
German constructive chemist
Flammarion, Camille
The popular astronomer of France
Flamsteed, John
First Astronomer Royal of England
Fleming, Sir Sanford
Who joined ocean with ocean in Canada
Flexner, Simon
Leader in scientific medicine
Franklin, Benjamin
Founder of American experimental science
Franklin, Sir John
Hero of the North West Passage
Fraunhofer, Joseph
Foundation layer for modern spectroscopy
Frémont, John Charles
Pathfinder through the Rocky Mountains
Fresnel, Augustin Jean
Benefactor of ships that pass in the night
Freud, Sigmund
The founder of psychoanalysis
Friedel, Charles
Planner of chemical laboratories
Frobisher, Sir Martin
A follower of the lure of gold
Froebel, Friedrich Wilhelm August
Apostle of teaching through play
Fulton, Robert
The first successful steam navigator
Galen
Physiologist at the dawn of Christianity
Galileo
Discoverer of the laws of motion
Gallaudet, Thomas Hopkins
Scientific educator of the deaf and dumb
Galton, Sir Francis
Founder of the science of eugenics
Galvani, Luigi
Discoverer of animal magnetism
Gama, Vasco da
Discoverer of the maritime route to India
Garrison, William Lloyd
Who made the Land of Freedom free
Gay-Lussac, Joseph Louis
Discoverer of the law of volumes
Gegenbaur, Carl
Founder of modern comparative anatomy

Geikie, Sir Archibald
Foremost British geologist of to-day
Geikie, James
Student of climate before man's advent
George, Henry
Proposer of the single-tax system
Gibbs, Josiah Willard
The founder of chemical energetics
Gilbert, William
Greatest scientist of Elizabethan times
Gill, Theodore Nicholas
Interpreter of toxonomic facts in ichthyology
Gill, Sir David
Searcher of the skies from Africa
Goethals, George Washington
Who built the Panama Canal
Goethe
Poet who found evolution by insight
Goode, George Brown
Discoverer of the mystery of deep-sea life
Gorgas, William Crawford
Who made possible the Panama Canal
Grassi, Giovanni Battista
Famous Italian entomologist
Gray, Asa
Organizer of systematic botany
Grotius, Hugo
Who applied reason to foreign affairs
Guericke, Otto von
Discoverer of the air-pump
Guettard, Jean Etienne
The inventor of geological maps
Haeckel, Ernst
The German apostle of Darwinism
Hale, George Ellery
Inventor of the spectroheliograph
Hall, Charles Francis
New Hampshire arctic explorer
Hall, Sir James
British explorer of volcanoes
Hall, James
First New York State geologist
Halley, Edmund
Discoverer and predictor of comets
Hargreaves, James
Inventor of the spinning-jenny
Harvey, William
Discoverer of the circulation of the blood
Hedin, Sven Anders
Explorer of the Central Asian desert
Hegel, Georg Wilhelm Friedrich
The greatest of the idealists
Helmholtz, Hermann Ludwig von
Explorer of the eye and ear
Helmont, Jean Baptiste von
Half scientist, half charlatan
Henry, Joseph
A great experimenter in electricity
Heraclitus
First of the great evolutionists
Herbart, Johann Friedrich
Who brought mind into education

Hero
Ancient applier of science to daily life

Herschel, Caroline
A great man's great sister

Herschel, Sir John
Tireless sweeper of the heavens

Herschel, Sir William
Breaker of the barriers of the sky

Hertz, Heinrich Rudolf
The discoverer of Hertzian waves

Hewitt, Peter Cooper
A millionaire devoted to invention

Hipparchus
Greatest of ancient astronomers

Hippocrates
Justly called the father of medicine

Hitchcock, Charles Henry
Distinguished son of a like father

Hitchcock, Edward
Educator who popularized geology

Hobbes, Thomas
Defender of autocratic sovereignty

Hofmann, August Wilhelm von
Extractor of wealth from waste

Hooker, Sir Joseph
A great evolutionary botanist

Howard, Leland Ossian
Head of the U. S. Bureau of Entomology

Howe, Elias
Inventor of the sewing machine

Howe, Samuel Gridley
An educator through the sense of touch

Hudson, Henry
An Elizabethan in quest of the North Pole

Huggins, Sir William
Pioneer in the field of astrophysics

Hughes, David Edward
Inventor of the microphone

Humboldt, Alexander von
Student of the distribution of life

Hume, David
A skeptic who reasoned reason away

Hunter, John
Early contributor to surgical science

Hutton, James
True father of modern geology

Huxley, Thomas Henry
Researcher, fighter and truth-seeker

Huygens, Christian
An Astronomer who made clocks

Jacobi, Abraham
Fighter for the welfare of children

Jacquard, Joseph Marie
Inventor of the pattern-making loom

James, William
The teacher of pragmatism

Jenner, Edward
Conqueror of a foul disease

Joliet, Louis
Early explorer of the Mississippi Valley

Joule, James Prescott
Who announced the immortality of energy

Kane, Elisha Kent
Organizer of systematic arctic research

Kant, Immanuel
The philosopher who looked within

Keeler, James Edward
Astrophysicist and student of Nebulæ

Kekulé, Friedrich August
And the Valency doctrine in organic chemistry

Kelvin, Lord
Great of intellect and of invention

Kepler, Johann
Discoverer of unity in the solar system

Koch, Robert
Discoverer of the cause of consumption

Kolliker, Rudolph Albert von
Founder of the microscopic anatomy

Laennec, René
Inventor of the stethoscope

Lamarck, Jean Baptiste
Real founder of organic evolution

Langley, Samuel
Maker of first power-driven airplane

Lankester, Sir Edwin Ray
Effective lecturer, popularizer of science

Laplace, Pierre Simon
The diviner of celestial mechanics

La Salle, René Robert, Sieur de
Discoverer of the Ohio, explorer of West

Lassalle, Ferdinand
Originator of German social democracy

Lassell, William
A great discoverer of satellites

Lavoisier, Antoine Laurent
The godfather of oxygen

Le Blanc, Nicolas
A creator of wealth who died poor

Lecky, William Edward Hartpole
An anti-democratic philosopher

Le Conte, Joseph
Of a family of five distinguished scientists

Leeuwenhoek, Anton von
The man who first saw protozoa

Leibnitz, Gottfried Wilhelm von
An encyclopædic genius

Leidy, Joseph
Founder of vertebrate paleontology in America

Leverrier, Jean Joseph
A discoverer of Neptune

Lewis, Meriwether
Commander of the Lewis and Clark Expedition

Liebig, Justus von
Founder of German chemical industries

Linnæus, Carolus
Who indexed the book of Nature

Lister, Lord
The savior of millions of lives

Livingstone, David
Opener-up of the Dark Continent

Scott, Robert Falcon
The tragic hero of the South Pole
Secchi, Father Angelo
Distinguished Italian astronomer
Sedgwick, Adam
An expert in stratification
Seelinger, Hugo
Student of the construction of the heavens
Seneca
The Stoic Roman philosopher
Shackleton, Sir Ernest
Discoverer of the south magnetic pole
Siemens, Ernest Werner von
A great benefactor of Germany
Siemens, Sir William
German engineer who helped England
Silliman, Benjamin
Geologist, chemist, physicist
Smith, Adam
Who made political economy a science
Smith, Captain John
Founder of Anglo-Saxon America
Socrates
The great truth-seeker by inquiry
Soddy, Frederick
An alchemist of the new school
Spencer, Herbert
Philosopher of universal evolution
Spinoza, Benedict
Who saw all things as the vesture of God
Stanley, Henry Morton
Founder of the Congo Free State
Stefansson, Vilhjalmur
Canadian-born arctic explorer-ethnologist
Steinmetz, Charles Proteus
A wizard of electricity
Stephenson, George
The founder of railways
Stephenson, Robert
Famous builder of bridges
Struve, Otto Wilhelm
Who found Saturn's rings are falling in
Suess, Edward
Founder of the new geology
Sverdrup, Otto Neumann
Norwegian arctic explorer
Tasman, Abel Janszoon
Dutch discoverer of Tasmania
Thales
Father of philosophy, one of the Seven Sages
Thomson, Sir Joseph John
The discoverer of ultimate matter
Tisserand, Felix
Exponent of celestial mechanics
Tolstoy, Count Leo
Famous Russian thinker and writer
Torrey, John
One-time chief of American botanists
Torricelli, Evangelista
A Columbus of the world of air
Trevithek, Richard
Pioneer of steam locomotion
Tyndall, John
Experimenter and expounder of science
Van't Hoff, Jacobus Henricus
Revolutionizer of organic chemistry
Verrill, Addison Emery
Zoologist, geologist, paleontologist
Vesalius, Andreas
The father of modern anatomy
Vespucci, Amerigo
The man after whom America is named
Virchow, Rudolf
The founder of modern pathology
Volta, Alessandro
Discoverer of the electric battery
Voltaire
A most brilliant French writer
Wallace, Alfred Russel
And the theory of evolution of species
Watt, James
Inventor of the real steam engine
Wedgewood, Josiah
The king of English potters
Weismann, August
A great student of heredity
Welch, William Henry
Pioneer in pathological laboratory work
Werner, Abraham Gottlob
Collator of facts in geology and mineralogy
Wheatstone, Sir Charles
Measurer of the speed of electricity
White, Gilbert
Natural historian of a village
Whitney, Eli
Inventor of the cotton-gin
Whitney, Mary Watson
One of foremost scientific women of her time
Wilberforce, William
The great emancipator
Wilson, Alexander
The father of American ornithology
Winchell, Alexander
Philosopher, geologist and paleontologist
Winchell, Newton Horace
Geologist of the great Northwest
Wöhler, Friedrich
One of the founders of organic chemistry
Wright, Sir Almroth
Defender of mankind against bacterial diseases
Wright, Wilbur and Orville
The first men to fly
Wyman, Jeffries
The gentle and unassuming naturalist
Xavier, St. Francis
Missionary explorer in the Far East
Xenophon
The originator of the literary essay
Young, Thomas
Who upset some of Newton's ideas
Zittel, Karl Alfred von
Paleontologist, classifier of fossil sponges

NATURALISTS AND BIOLOGISTS

LOUIS AGASSIZ

The First Naturalist of His Time

JEAN LOUIS RODOLPHE AGASSIZ, one of the most popular men of science of the second and third quarters of the nineteenth century and a strong and consistent opponent of the Darwinian theory, was born at Motier, in the Canton of Fribourg, Switzerland, on May 28, 1807, the son of a clergyman. His education, begun at Lausanne, was continued at Zurich, Heidelberg, Erlangen and Munich. He was graduated in medicine and took a further degree in philosophy. His taste for zoölogy, developed by his early studies, brought him in Munich into relations with Martius and Spix, and his arrangement and description of the latter's collections of Brazilian fishes attracted the attention of Cuvier, whose pupil he became in Paris. When only twenty-four years old he was appointed professor of natural history at Neuchâtel and it was during the fourteen years he retained that chair that he completed his first great work on fossil fishes ("*Recherches sur les poissons fossiles*," 5 volumes). From fishes he enlarged the range of his observations to invertebrate animals, which he studied in both living and fossil forms, and he quickly obtained a European reputation. In England in 1834 he made the acquaintance of Hugh Miller, and by his appreciation of the studies of the Scottish stone mason helped to popularize that unfortunate genius. His visits to the British Isles resulted in his "Fossil Fishes of the Old Red Sandstone." On his return to Switzerland, Agassiz took up the study of glacial movement and his theories attracted universal attention.

In 1846 he was invited to deliver a course of lectures at the Lowell Institute in Boston, and these were so much appreciated that he was appointed professor of natural history in the Lawrence Scientific School of Harvard, and joined the circle of delightful men who in that day gave Cambridge distinction in the world of literature. One of his innumerable activities was the foundation there of the Museum of Comparative Zoölogy, one of the most extensive and scientifically useful in the world. To its development he devoted his enormous energy and enthusiasm, obtaining public and private subscriptions for its extension and maintenance and remaining always poor from his own liberality to it. Even the holidays which so rarely diversified his strenuous work were spent in scientific excursions, and carried him as far afield as Brazil (1865). His investigations in the Alps had convinced him of the need for the study of nature where the objects under observation were *in situ*, and he therefore established on the island of Penikese, in Buzzard's Bay, a practical school of marine zoölogy. This was the precursor of all the summer schools that have since done so much for the encouragement of scientific knowledge. Among a number of other important works published during these years was "Contributions to Natural History of the United States," in four magnificent volumes.

THE FOUNDER OF SYNTHETIC CHEMISTRY

PIERRE MARCELLIN BERTHELOT, ONE OF THE MASTER SCIENTIFIC MINDS OF MODERN FRANCE

CHEMISTS AND PHYSICISTS

ANDRÉ MARIE AMPÈRE

From Whom is Named a Unit of Electrical Measurement

ANDRÉ MARIE AMPÈRE was born at Polémieux near Lyons, France, in 1775. From his earliest youth the study of figures had a peculiar fascination for him, and his father, discovering his bent, allowed him free scope and ceased to urge upon him the study of the ancient languages. Ampère, however, was catholic in his tastes and after a brief respite returned to his Latin, that he might read the works of the great Swiss mathematician Euler and Bernouilli. He was accustomed, later in life, to say that he knew as much about mathematics when he was eighteen as he ever knew; but his reading embraced the whole round of knowledge — history, travels and science. There was perfect sympathy between father and son, and when in 1793 the former was guillotined, the tragedy produced so great an effect upon the son's mind that for a year he did no work and remained sunk in melancholy. A new study aroused him; some letters on botany fell into his hands, and he sought solace in the study of nature and the Latin poets. Moreover, his mind was further distracted from his grief, as at this time he fell in love with a young girl, Julie Carron of Lyons, and in 1799 the two were happily married. After 1796 Ampère earned his living as a private tutor of mathematics in Lyons.

In 1801 he moved to Bourg to become professor of physics and chemistry in the Central School of the department of Ain, leaving his ailing wife and infant son at Lyons. She died in 1804 and he never recovered from the blow. In that same year he was appointed professor of mathematics of the lycée of Lyons, and a treatise, *Considérations sur la théorie mathématique du jeu*, written at the time, gained for him a position in the Polytechnic School in Paris, where he was made professor of mathematics in 1809. In 1814 he was elected a member of the Academy of Sciences and in 1824 was appointed professor of experimental physics in the College of France. He died at Marseilles on the 10th of June, 1836.

As the "New International Encyclopedia" says:

"Science is largely indebted to Ampère, especially for his electrodynamic theory and his original views of the identity of electricity and magnetism. He was the inventor of the astatic needle which made possible the modern astatic galvanometer, and he was the first to show that two parallel conductors carrying currents traveling in the same direction attract each other, while if traveling in opposite directions they repel each other. He also formulated the theory that there were currents of electricity circulating in the earth in the direction of its diurnal revolution which attracted the magnetic needle."

He also introduced, many years before this, the principle of using the spent fumes from an engine furnace to heat the steam on its way from the boiler to the cylinder. Though this idea was not fully carried out at the time, it has since proved of great importance in increasing the efficiency of steam engines. In 1859 he became a British subject and in 1883 was created a baronet. He died in London, on November 19, 1883. Like his brother, Werner, he took an important part in the development of electric power, and was one of the first men to obtain a strong electric current from falling water by means of a water-wheel and a dynamo. Together they laid the direct Atlantic cable from the *Faraday*, a ship especially designed by him for the purpose.

CHARLES P. STEINMETZ

By choice, a mathematician; by circumstances, an electrical engineer

CHARLES PROTEUS STEINMETZ had a brilliant record in the fields both of mathematics and electrical engineering, yet his early ambition was not concerned with electricity. As far as he had any definite aspiration, he had set his heart upon becoming a professor of mathematics in his native country — Germany. When he came to America, after a sudden dramatic withdrawal from his homeland, circumstances more than anything else brought him into business relations with Rudolph Eickemeyer, of Yonkers. And there he became linked inseparably with electrical affairs and their problems.

Steinmetz was born on April 9, 1865, in Breslau, capital of the south German province of Silesia. His father was Carl Heinrich Steinmetz, an expert lithographer, employed at that time in the headquarters office of the Ober Schlesische Railroad. His mother died when he was a year old. The name given him at his christening was Carl August Rudolph Steinmetz, and under that name he began going to school at the age of five. He entered the University of Breslau, at the age of 17, and first attracted attention by attending every lecture in mathematics and astronomy during his first year. Thereafter he studied six subjects every year, yet joined heartily in all the student merry-makings as a member of the undergraduate mathematical society. When he joined the latter, his fellow students gave him the nickname of "Proteus".

He not only worked hard at his studies but also affiliated himself with a small group of students who formed part of the German socialist movement. For a couple of years he took part in secret meetings, read socialist literature and even helped get out a socialist newspaper. But at length the activity of Bismarck's police resulted

DR. CHARLES P. STEINMETZ

in the arrest of many of Steinmetz's friends, including several students, and his own apprehension. To escape a prison sentence, he hurriedly departed from Germany early in 1888, just as he was about to receive his university degree.

He went secretly to Vienna and thence to Zurich, where he studied mechanical engineering for a year at the university there. Then, falling in with a young friend from America, he decided, in an adventurous moment, to accompany the latter to the United States. He had so little money, however, that he accepted the offer of his friend to pay his traveling expenses.

THE IRIDESCENT BEAUTY OF GLASS

Courtesy Louis C. Tiffany Furnaces

Five typical vases of Favrile glass, graceful in shape and glowing in opalescent colors that rival nature's brilliancy.

Household Science

WOMAN'S sphere may be the home, but the men and children have to live in it and they are equally interested that it should be well planned, suitably equipped, competently maintained, economically administered. The chapters in our book on these and allied subjects are by members of the teaching staff of the Department of Household Science of Toronto University. They are the last word in practical domestic affairs.

The Building of the House
Planning and decoration of the house
Deciding on type and material
Getting the utmost in plan and design
The various rooms and their relation
Color, how it should and should not be used

The Kitchen as a Workshop
How to make it convenient and pleasing
Shelving and other provision for storage
Grouping of the movable equipment
Choice of permanent equipment
Stoves, sinks, tables, floors and walls

Woodwork and Fittings
Selection and care of wood and metals
Wood finishes: painting, oiling, staining, filling, varnishing and waxing
Metals appropriate for household equipment and how to keep them clean

The Cleaning of Fabrics
The removal of stains, and bleaching
The use of bleaching powder or chlorated lime, hydrogen peroxide, oxalic acid and salts of lemon
Some special stains and how to treat them
The danger of grease solvents and how to avoid it

Clothes and Laundry Reagents
Laundry soaps and washing compounds
Even pure soap must be rinsed away lest, drying in the fabric, it turn the clothes yellow
Few products on the market have such a varied composition as "soap"

Choice and Care of Fabrics
How to recognize fibers, quality and value
Tests that show whether materials are what they claim to be
Deceptions that weave, filling or finish can "put over" on the unsophisticated

Family and Household Budgets
What and where to spend and how to save
How to make both ends meet at the end of the year
Proportion of income that should be devoted to rent, food, dress and entertainment

A Factor in National Progress
What makes a nation's greatest asset
Average height and weight of men, women and children at different ages
Proper food an important factor in mental and moral as well as physical development

Starches and Sugars
What the carbohydrates have to offer
Widely distributed and comparatively cheap sources of food material
Starches and sugars as suppliers of needed body fuel, and their digestion

Vegetables as Food Material
What a kitchen garden has to offer
Composition and value as set forth by the U. S. Department of Agriculture
Comparative digestibility and how best to prepare them for the table

The Various Cereals
One of the oldest forms of human food
The admirable structure of a tiny grain of wheat
Digestibility of cereal proteins as shown by experiment
Preparation of ready-to-eat cereals

Fruits and Nuts
Seed-bearing organs of plants as food
Delicious elements, even sole constituents of a satisfactory diet
Orange juice especially suited to children
The preserved fruits that offer an infinite variety

Milk and Milk Products
The most important single food
Vitally essential for growing children, milk is a factor of safety in any diet
The efficiency of milk proteins for growth shown in striking illustrations
Whether cheese is indigestible depends on the state in which it is eaten

Eggs and Egg Substitutes
Their actual and comparative value
Differences in appearance between fresh, stale and bad eggs
The prejudice against cold storage eggs
The composition, food value, economic value and digestibility of eggs and egg substitutes

Flesh Foods and their Value
The proper use of meat flesh and fowl
How much do we waste, how much do we get out of a lamb chop?
What part of the animal the different retail cuts of beef come from
Tests indicating powers of endurance of flesh-abstainers greater than those of flesh-eaters

THE BUILDING OF THE HOME

"Houses Are Built to Live in
and not to Look on." — Bacon

THE PLANNING AND DECORATION OF THE HOUSE

THE building of a home is an important undertaking, as it involves a considerable investment, which should increase and not decrease in value. In order that it shall be satisfactory in every detail to the owner, it is necessary to study carefully all the problems involved. The first one is that of finding a suitable location. Many factors must be considered, such as accessibility to the owner's place of business, nearness to school, purity of water supply, drainage possibilities, sewage disposal, water, gas and electric facilities, suitability of soil for building purposes, kind of neighbors, and whether or not property in the neighborhood is restricted.

Deciding on type and material

When the site has been selected it is necessary to determine the proportions of the building to be constructed. The house should be placed to get as much light and sunshine as possible in the rooms most used. A flat location is more suitable for a formal type of Colonial or Renaissance house. Irregular, sloping land with shrubbery and many trees offers opportunity for very informal, rambling houses of the English cottage type. Curving walks, winding roads, and irregular gables showing through the trees are very picturesque but need a rather spacious location. Again, a house must not only be suited to the land on which it stands, but should blend harmoniously with the houses in the near neighborhood. A very plain, severe type of Colonial house is out of place on a street where there are many rambling cottages with spacious lawns.

After the type of house has been decided upon, the kind of material used in construction should be studied. It is always cheaper to buy building material which is near at hand because transportation considerably increases cost. However, certain types of houses suggest at once a standard material. For example, a true Colonial house suggests wood with very wide clapboards; an English half-timber house suggests brick or stucco and timber. Frame construction is usually the cheapest, but the life of a frame house is many years shorter than that of a brick veneer, stucco, brick on tile, or solid brick, and, furthermore, is expensive to keep in repair. The walls need paint every two years, and where there is a great deal of dampness the wood decays quickly and needs to be replaced. Solid brick construction is usually the most expensive but its life is longest.

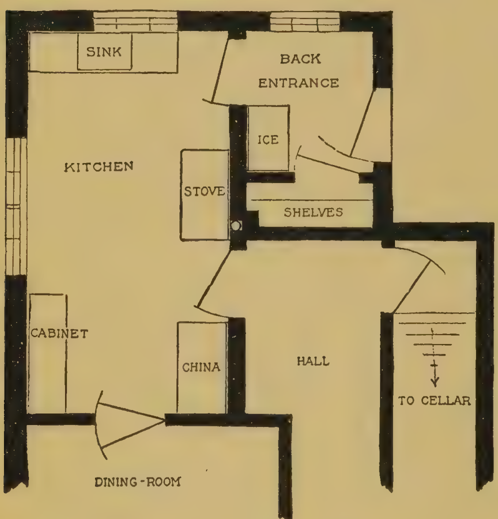
Getting the utmost in plan and design

After one has found a location, studied a possible type and material, one should secure the services of an architect. It is not absolutely necessary, but it is wiser, in order to get the utmost in plan and design. The prospective owner should be unwilling to risk the expenditure of so large a sum of money as is required in the building of a house without feeling sure that it is being wisely used and that he will get the largest possible return. Houses built by an ordinary builder and contractor, without the aid of a trained architect, are lacking in design and beauty, well built though they may be. And there is nothing incompatible between beauty and comfort.

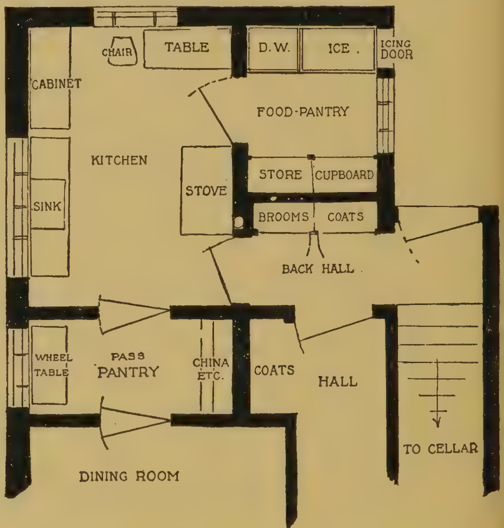
The most suitable aspect is north, northeast, or northwest so that, while being cool, the room may have good light. Two outside walls are desirable in order to get sufficient light and ventilation, and to keep down the temperature, so that the best location is on a corner of the house or in a wing. The windows should provide sufficient light to obviate the necessity for artificial light at any working-center during the day. Usually their total area should be at least twenty-five per cent of the total floor area and they should be so arranged as to allow of cross ventilation between themselves or between them and the outside door.

The position of the doors so as not to break up the available wall space is very important, and the direction in which they open makes a great difference to the comfort of the room. Swing doors between kitchen and pantry, and between pass-pantry and dining room are desirable.

The size of the kitchen depends somewhat on the size of the household and whether the room is utilized for food work only. It must be large enough to accommodate an extra worker on occasion. It depends also on what kind of fuel is being used, for with a coal range more heat is radiated into the room than from electricity or gas, and it must be somewhat fur-



A BADLY-PLANNED KITCHEN



THE SAME KITCHEN REARRANGED

It is better that the tops of the windows should not be more than one foot from the ceiling, as the hot air of the room rises and will tend to remain in any space above the top of the window. It is a good plan to have one opening extending to the top of the room. A small transom which tips and can be opened by a rope over a pulley could well be placed near the ceiling for the escape of the hot air if the windows are not high enough. Sash windows, easy to lower and raise, are better than casement windows for a kitchen, and if the distance from the floor to the bottom of the window is from three to four feet, there is room for a table or a sink beneath.

ther removed from the worker, and accommodation must also be made for its fuel. It has been found as a matter of practical experience that for an ordinary small household, the area of the kitchen and pass-pantry together should be about one hundred and fifty square feet if gas or electricity is used, and about two hundred square feet if coal is used. Eight feet is the minimum width for a kitchen, but the actual measurements must, of course, vary to fit into the plan of the remainder of the house. An approximately square kitchen is usually more convenient than a long, narrow one. In too small a kitchen the worker has no freedom of movement and soon becomes cramped.

A DESCRIPTIVE COLOR CHART

THE OUTER CIRCLE SHOWS THE NORMAL, FULL INTENSE PRIMARIES, BINARIES, AND HUES.
THE INNER CIRCLE SHOWS HALF-NEUTRALIZED PRIMARIES AND BINARIES AS THEY APPROACH THE BACKGROUND POSSIBILITY.
OPPOSITE TONES IN THE CIRCUIT ARE CALLED COMPLEMENTS.

From "Interior Decoration," by Frank Alvah Parsons

The meaning of color

It is well known that certain color tones produce certain impressions in people, and therefore express, consciously or unconsciously, certain qualities; and colors can be used to the best effect only when their meaning is fully grasped.

Yellow gives the effect of light and brightness, and of sunshine. It makes a room cheerful when introduced in any shade. It is not necessary to use full, intense, normal yellow, but one of the more delicate tones of yellow, such, for example, as cream. If used in a strongly lighted room, it may produce a glare unless the quieter or grayed shades such as buff or tan are chosen, but at the same time, there should be enough yellow in the tan to prevent it from being dull or ordinary.

Red (not vermillion, which is really a red-orange, but rather a crimson) suggests warmth and life. Red-orange may suggest excitement or irritability. Red is therefore rather a difficult color and often very unsuitable to use in any quantity, but rose and the softer crimsons are useful, particularly if blended with other colors, in fabrics. Red used with discrimination may suggest hospitality.

Blue is cold and non-aggressive and gives the sensation of coolness, repose, restraint and formality. The various tones of blue are often discordant and are difficult to blend. Blue of a certain shade and old ivory make a very artistic scheme of coloring; but the effect is cold unless relieved by a touch of rose or gold.

Green is a mixture of yellow and blue, and, unless the yellow predominates, is a cool, retiring color. In its slightly grayed

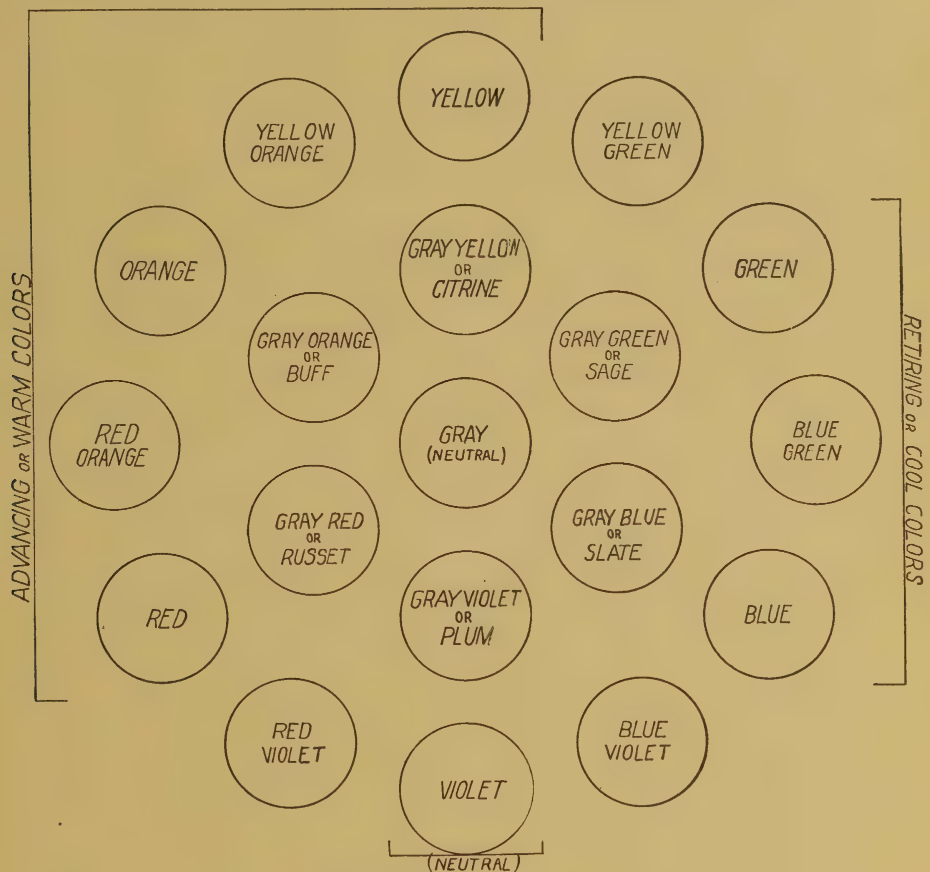
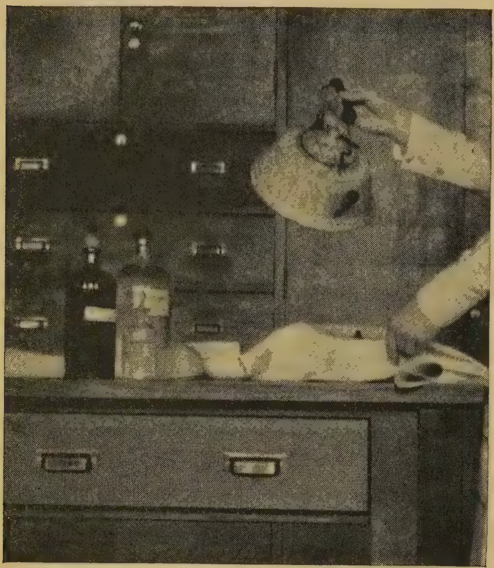


FIG. 4. KEY TO COLOR CHART

What to do if cold water is ineffective

If, however, cold water is found to be ineffective, use warm water or warm water with a very little borax or ammonia dissolved in it. This will remove many freshly made fruit, tea and coffee stains. A delicate material may be sponged gently. Hot water poured from a height of about twelve to eighteen inches through the fabric stretched over a basin is often very effective in cases of cooked fruit stains.



Pouring hot water from a height of 12–18 inches through a stained fabric.

Many stains can be removed by a prolonged exposure to light and air, and this method causes the least possible deterioration in the fabric. It consists in spreading the wet fabric on the grass or on a towel in the sun, and as it dries, remoistening with water. Several days' exposure may be necessary, but will usually remove many obstinate stains as well as the yellow tinge which clothes acquire with incorrect washing methods or on storage. The whiteness of clothes which are habitually dried in the sun and air is due to this mild bleaching process. The process is one of slow oxidation, but owing to the time required, and the impracticability in towns, it is often necessary to resort to more rapid methods of bleaching where simple treatment fails.

The bleaching agents and stain removers which can be used conveniently in the home laundry are:

(1) A solution of bleaching powder or chlorinated lime known as "bleaching liquor"; or the solution of the corresponding sodium compound known as "Javelle water."
(2) Hydrogen peroxide.
(3) Oxalic acid or the corresponding potassium compound known as "salts of lemon."
(4) Benzine, benzol, gasoline, methylated spirits and turpentine, for grease, paint, tar, etc.

The use of bleaching powder or chlorinated lime

Bleaching powder is made by passing chlorine gas over slaked lime (calcium hydroxide). The active agent in the resulting compound is the chlorine after it is set at liberty again. It is then known as "available chlorine." A fair sample of freshly prepared bleaching powder contains about 30 to 35 per cent available chlorine, but on keeping, or on exposure to the air and moisture, it tends to decompose and lose some part of this. It is entirely unsuitable to use on silk or wool, the fibers of which are rendered harsh and brittle even by dilute solutions. Its use is restricted to the bleaching of linen and cotton (cellulose materials), and even these may be affected by carelessness — linen more easily than cotton.

Bleaching liquor of the greatest strength which experience shows is safe to use is prepared by mixing one ounce of the powder to a creamy consistency with a little water, then diluting to one gallon with warm water. This should be well stirred and when solution is complete, allowed to settle. This solution of calcium hypochlorite ($CaOCl_2$) will contain about 0.2 per cent available chlorine. The clear liquid only should be used. If the fabric is immersed in the turbid liquid, there will be overbleaching with the formation of oxy-cellulose where the solid matter comes in contact with the fabric; and tendering, or even destruction, of the fibers at these places will follow.

EGGS AND EGG SUBSTITUTES

An Important Item in the Dietaries
of Growing Children and Invalids

THEIR ACTUAL AND COMPARATIVE VALUE

EGGS of various kinds were doubtless one of the earliest foods and they are still a common article of diet throughout the world. The eggs of domesticated fowls are the ones which are principally used, although the eggs of wild fowl, birds, fish and some reptiles are also edible. The latter varieties, however, are so rare and so difficult to obtain that they are not of commercial importance. Since hens' eggs are so much more available than all others, statements here made may be understood to refer to them.

The production of eggs is widely distributed. They are produced on almost every farm in the United States and Canada. Generally speaking, the months of March, April, May and June are those in which the largest number of eggs are laid and it is during this time that many are put away for winter use.

Eggs are graded for the market according to freshness, size, color, cleanliness and cracks. The sorting according to size, color, cleanliness and large cracks can be done readily by the unaided eye, but where the cracks are very fine they can be detected only by clicking two eggs together (a cracked egg, tapped against an uncracked one, gives a deadened sound), or by candling. The first grading by the unassisted eye or ear is comparatively easy, but it takes experience to be able to determine the condition of an egg by "candling", that is, by holding it before a strong light and allowing the rays to come to the eye through the partially transparent shell and contents. Eggs can best be candled in a dark room by using a bright light inclosed in a box (an "egg-tester") with a hole in it slightly smaller than the egg, directly in front of which the egg is held for examination. The egg should be given a few moderately rapid twists to the left and right, thus bringing the entire surface to view. By this means the size of the air space and condition of the white and yolk may be observed. The air space of a fresh egg is less than three-quarters of an inch in diameter, but owing to the evaporation of water from

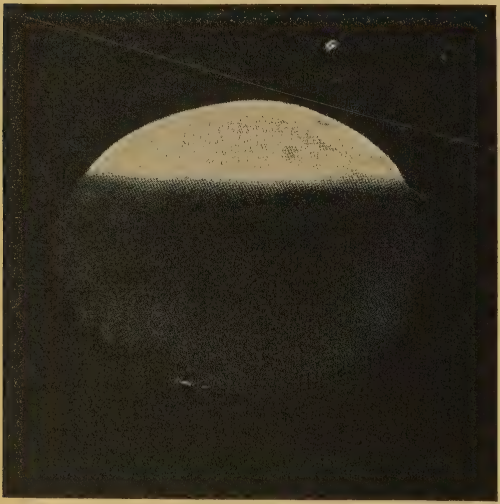
NEW LAID EGG

the liquid contents, it increases as the egg grows older. The white of a fresh egg should be firm and thick, and in candling its condition is determined by the action of the yolk. When the egg is fresh the yolk remains nearly stationary, but in an older egg the yolk moves quite rapidly. When a fresh egg is turned, the yolk is seen dimly as a dark, shadowy object which moves slowly; in a stale one, the

yolk appears plainly and moves rapidly, due to the thinness of the white. A bad egg may be readily detected from the fact that it appears dark and opaque instead of clear and transparent. Eggs sufficiently good to pass the candling test may then again be divided into many grades, according to color, size, cleanliness, etc.

TYPICALLY STALE EGG

After candling, eggs are ready for the market or for preservation. Since eggs are usually abundant and reasonable in price during the spring and early summer, they may be profitably preserved at that time for use during the winter when they are scarce and expensive.



TYPICALLY BAD EGG

Some methods of preserving eggs

Eggs may be preserved in either of the two following ways:

(1) By coating, covering or immersing the egg in some material to prevent evaporation of water from the egg contents and to prevent the entrance of organisms. This method has been in use for many years, and bran, salt, sawdust, etc., have been the materials most frequently used. After much experimenting, however, the best results have been obtained by immersing the eggs in a solution of sodium silicate, or "water-glass". This material cannot be used commercially but good results have been obtained when it is used in home preservation, if precautions are taken before starting to see that the eggs are clean, fresh, free from cracks, etc.

(2) By a low temperature, as in cold storage. The preservation of eggs by cold storage is a commercial process and enables us to have a perishable food available at all times. That egg production is much higher and prices much lower in early spring than in the fall and winter, is a fact of which dealers make use. The surplus supply of the spring months is bought up and put into storage to await the season of scarcity and increased prices. Although storage eggs even during the winter do not reach the price of fresh eggs, still the price is sufficiently above the amount paid for them to yield a profit after storage expenses have been paid. Once in a while we see an article in the press calling attention to the fact that the cold storage men are receiving large profits which rightfully belong to the farmer, and advising the farmer himself to send eggs to cold storage or preserve them in some other way. As a matter of fact such advice is unwise, for the shipping, storing, insuring and selling of the individual cases of eggs would eat up all possible profit.

The prejudice against cold storage eggs

It is a well-known fact that the majority of people have a strong prejudice against cold storage eggs, and this is due no doubt to the characteristic flavor and their behavior in cooking. In a recent investigation

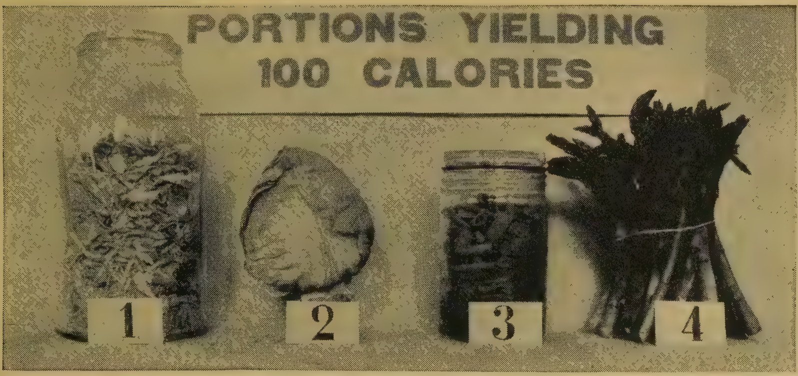


FIG. 1. 100-Calorie portions
1. Shredded cabbage in a 2 quart sealer
2. Cabbage
3. String beans (cooked) in a 1 pint sealer
4. Asparagus

FIG. 2. 100-Calorie portions
1. Spinach
2. Spinach (cooked) in a 1 pint sealer

Vitamin C, which has notable antiscorbutic properties, is present in large quantities in tomato and cabbage and makes them particularly good antiscorbutics. Both rank very high and compare favorably with orange juice. Cooking is found in most cases to diminish or entirely destroy the efficiency of a vegetable as an antiscorbutic. For example, cabbage cooked for one hour at 140° F., or twenty minutes at 194° F., lost about 70 per cent of its antiscorbutic value, and for one hour at 194°F. more than 90 per cent. Vegetables which have been cooked a long time or canned are thus of little value as antiscorbutics. There is one important exception to this, canned tomato, which has been successfully used as a substitute for the more expensive orange juice to prevent scurvy in infants receiving pasteurized milk. Drying has been found to lessen the value of an antiscorbutic food, but dried tomatoes still retain a significant amount of the original high antiscorbutic potency.

The small amount of carbohydrate (sugar and cellulose) which the green vegetables contain also adds to their value. They are usually classed as 5 per cent vegetables because the carbohydrate content is approximately that amount. In special diets where it is necessary to restrict the carbohydrate intake, such as in diabetic diets, the 5 per cent vegetables are given an important place. In planning the ordinary diet it is advisable to add some vegetable for the sake of minerals, vitamins and bulk without increasing the total fuel value to any great extent. This can be done by introducing the 5 per cent vegetables.

These vegetables are very important sources of cellulose. For example, one average serving of cabbage, of cauliflower or of spinach supplies more than twice as much cellulose as one of rolled oats. This cellulose, acting as roughage, aids in increasing the peristaltic movement in the intestine, which is so essential in maintaining health.

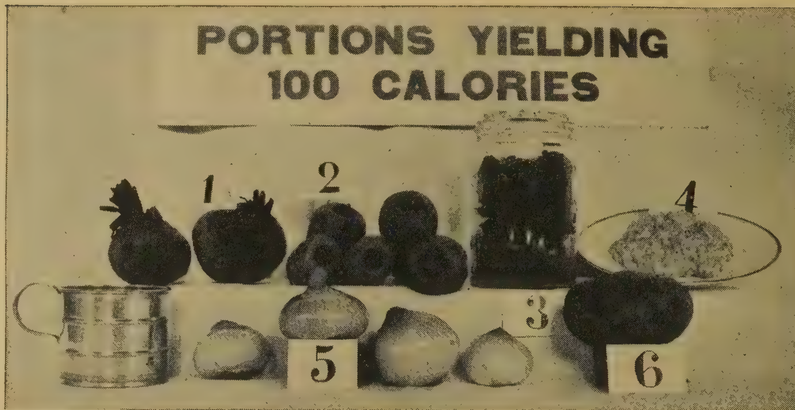


FIG. 3. 100-Calorie portions
1. Beets
2. Carrots
3. Carrots (cooked) in a 1 pint sealer
4. Mashed potatoes
5. Onions
6. Potato
The mug is a standard half-pint cup

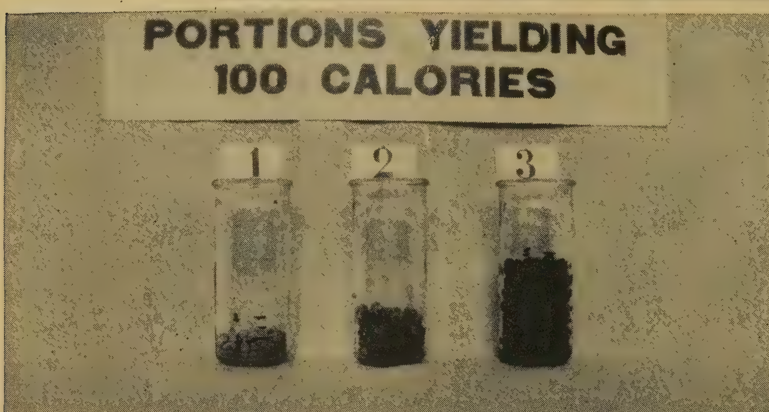


FIG. 4. 100-Calorie portion of peas
1. Dried peas
2. Dried peas soaked
3. Fresh green peas
All are in 8 oz. jars

Roots, tubers and bulbs may be regarded as reserves of nourishment for the use of the plant itself. Knowing this fact, it would naturally be expected that the vegetables included in this group would supply a larger quantity of actual food material than is found to be the case with green vegetables. The percentage composition of roots, tubers and bulbs shows that this is true.

For example, whereas the total of the solids of green vegetables do not amount to more than 8 per cent, the solids of roots and tubers are found to range between 10 per cent in the turnip and 30 per cent in the sweet potato. The carbohydrate averages between 15 and 20 per cent, the protein about 2 per cent, the mineral matter 1 per cent, while the fat, as in green vegetables, is present in almost a negligible quantity. The following table gives some idea of the caloric value of an ordinary serving of roots, tubers and bulbs (see figure 3):

DISTRIBUTION OF CALORIES IN 100-CALORIE PORTIONS

Vegetable	Approximate Measure of 100-Calorie Portion	Calories from		
		Protein	Fat	Carbohydrate
Beets . .	3–4 servings	14	2	84
Carrots . .	4–5 servings	10	8	82
Onions . .	2–3 servings	13	6	1
Parsnips .	3–4 servings	10	7	83
Potatoes .	1 medium-sized	10.5	1	88.5
Sweet potatoes	About $\frac{2}{3}$ size of white potato	6	5	89
Turnips .	3–4 servings	13	5	82

From the figures it will be noted that the amount of protein yielded by a 100-Calorie portion of these vegetables is considerably less than is the case with green vegetables. The latter give between 20 and 30 per cent of the calories from protein, whereas roots and tubers average only between 10 and 15 per cent; the sweet potato, below 10 per cent.

The relative value of milk to other articles of food may be seen in the following list abstracted from a table of Meara and adapted from Professor Irving Fisher.

TABLE OF FOOD VALUES IN UNITS OF 100 CALORIES

	Protein in Grams
Milk, 5 oz	5
Cream, 16 per cent (2 oz.)	1.5
Buttermilk, one and one-half glasses (9.5 oz.)	8
Koumys, one glass (7 oz.)	5
Whey, two glasses (13 oz.)	3.5
Eggs, one and one-half	10
Whites of eggs, 6	24
Yolks of eggs, 2	4.5
Oatmeal, one and one-half serving (5.5 oz.)	4.25
Boiled rice, ordinary cereal dish (3 oz.)	2.5
Hominy, large serving (4.2 oz.)	2.5
White bread, home-made, one thick slice (1.25 oz.)	3.2
Butter, one pat (0.5 oz.)	0.0
Sugar, three teaspoonfuls, one and one-half lumps (0.8 oz.)	0.0
Oil, one-third ounce	0.0
Codfish, two servings (5 oz.)	23
Salmon, small serving (1.5 oz.)	7.3
Oysters, 12	12
Roast beef, ordinary serving (1.8 oz.)	10
Small sirloin steak (1.4 oz.)	7.5
Leg of lamb or mutton, ordinary serving (1.8 oz.)	10
Bacon, small serving, medium fat (0.5 oz.)	1.5
Chicken, broiler, edible portion, large serving (3.2 oz.)	19
Potato, baked, one, good-sized (3 oz.)	3.75
Potato, sweet, baked, one-half average potato (1.7 oz.)	1.5
String beans, five servings (16.66 oz.)	3.75
Spinach, two ordinary servings (6.1 oz.)	3.7
Peas, green, one serving (3 oz.)	5.7
American or Swiss cheese, 1.5 cubic inches (0.75 oz.)	6
One baked apple (3.3 oz.)	0.5

From this table it may be seen that milk stands very high in food value. Estimating a glass of milk as one-half pint, four such glasses (a quart of good milk) will contain 600 to 700 calories — one-fourth of the daily need of the average adult — at a cost of 6 to 10 cents, constituting an economical source of food supply.

The disadvantages of milk as the chief or sole article of diet are first, the great dilution of the food elements in milk, which necessitates drinking a very large amount to satisfy the body requirements.

Thus the caloric needs of a healthy man of average weight and bodily activity would require the daily consumption of about a gallon of milk, — a quite impossible task for most individuals. Furthermore, the amount of nitrogenous substance thus ingested would be far in excess of the needs of adults, and as no provision is made for storing excess nitrogen in the body, as in the case of excess fats and sugar, this excess is excreted as body waste, chiefly by the kidneys.

Furthermore, milk diets do not furnish the bulky indigestible residue which is essential to most individuals for the regular evacuation of the bowels, such a residue as is commonly furnished by green vegetables and salads. In other words, milk is in a sense too perfect a food for adult needs.

Milk is the only animal food that in this country is commonly taken raw. It is unfortunately the food most readily contaminated by many organisms with consequent chemical changes affecting its taste or rendering it a source of danger to health and life by the conveyance of an infectious disease. In other words, milk is an excellent culture medium for many germs, pathogenic and non-pathogenic, but the former, while in themselves harmless, may occur in such enormous quantities as to render the milk unfit for infant consumption. Most of these organisms are found in the surrounding air, the walls and ceilings, straw bedding, hay, on the udders and flanks of cattle, unwashed hands of milkers, dirty milk pails, etc. Their presence in excessive numbers is indicative of poor equipment and lack of well-established methods of milk production, which include clean barns, clean cows, clean milkers, clean milk pails with small openings, prompt and continuous icing of the milk until it reaches the consumer.

In addition to non-pathogenic germs, milk may be and frequently is contaminated with those which are the cause of a number of infectious diseases. One of these, tuberculosis, is derived from the cow, which itself is suffering from the disease and, as a very large proportion of the ordinary dairy cattle in this country are so

affected, we should expect — and laboratory tests have shown — that many samples of market milk contain a greater or less number of tubercle bacilli. When such milk is taken raw by infants and young children, it may — and frequently does — set up in them tuberculosis of the intestinal tract, peritonitis, tuberculosis of the glands, especially in the neck, or the bones and joints, and not infrequently a generalized tuberculous infection ending in death within a short time, often from meningitis.

The records show that the danger of contracting tuberculosis by older children and adults from drinking such milk is almost negligible, the great majority of adult cases of tuberculosis coming from human and not bovine sources. Cattle tuberculosis, therefore, may be said to be confined to cows and other domestic animals, together with human beings under five years of age. There are other diseases which the cow may occasionally transmit through the milk. Two of these are intestinal anthrax, a very fatal disease, and a septic infection resembling scarlet fever but in all probability distinct from it.

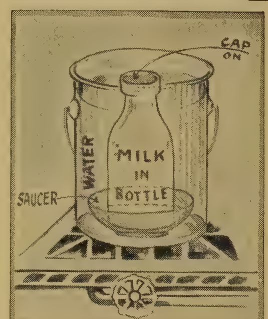
In addition to those diseases which come from an animal source, a number of diseases peculiar to man are due to infection of milk after it has been drawn by persons handling it who have themselves suffered from one of the diseases, are convalescent from it, or are carriers of disease germs; such an infection is brought about chiefly through the agency of contaminated fingers, indirectly through the medium of insects, especially flies, or through infected water used to clean milk utensils or to dilute the milk.

In communities which have established a pure supply of drinking water, the occurrence of outbreaks of typhoid fever may be said in almost every instance to be due to the contamination of a milk supply, most often by the carrier, unaware of his condition, who handles the milk at some stage of its production. Thousands of cases of typhoid are thus caused every year, with many deaths. Local epidemics of scarlet fever, diphtheria, and dysentery are frequently traceable to milk. Epidemics of septic sore throat have their origin almost solely in infected milk. In this disease the cow's teat is usually infected by hands contaminated with discharges from the throat and nose of the milker, who is himself sick with or convalescent from some form of septic infection, usually of the throat, or from an infected wound on the fingers or hand.

The health authorities in all progressive communities have come to recognize the

PASTEURIZATION IN THE HOME

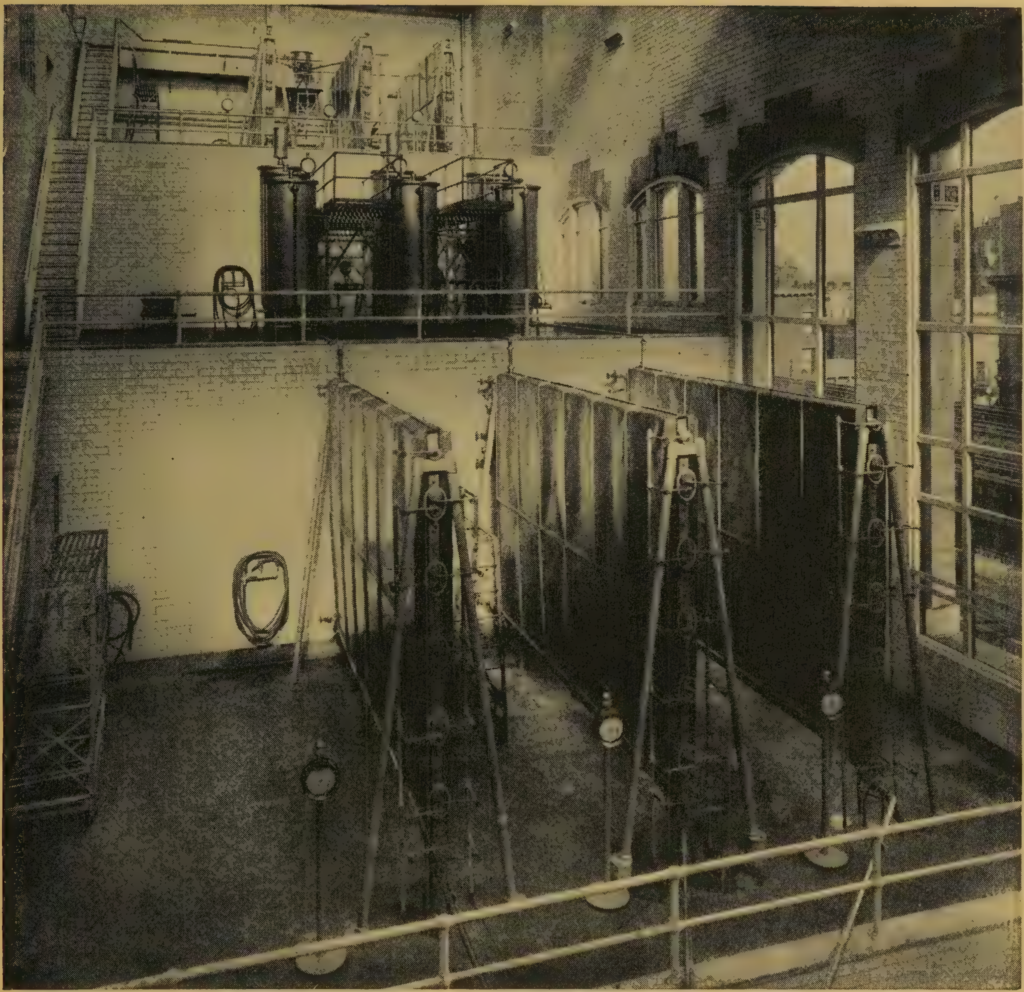
If you cannot buy pasteurized milk, raw milk should be pasteurized in the home



In a 3 or 4 quart tin pail place a saucer; stand bottle of milk (with cap on) on the saucer; pour enough warm water (not so hot as to break bottle) into the pail to fill it within two inches of top of bottle. Now stand pail and its contents on stove and heat until water begins to boil, then immediately remove bottle of milk from pail, shake and let stand half an hour, at room temperature, shaking two or three times. Then place the bottle in the icebox.

FACSIMILE OF PANEL FROM MILK EXHIBIT OF THE N. Y. STATE DEPARTMENT OF HEALTH

importance of milk as a vehicle for the transmission of infectious disease, and health regulations have been introduced for the handling of such diseases on dairy farms, and for the exclusion of all the milk from such farms from distribution until such time as appropriate quarantine measures shall have precluded the possibility of spreading the disease through contamination of the milk.



PASTEURIZING ROOM OF THE SHEFFIELD FARMS COMPANY

The different levels are utilized as follows;
Top landing, milk heaters — cold raw milk raised to 146° F.
Next landing, holding cylinders — hot milk retarded 50 minutes.
Next landing, coolers. The bottle fillers and cappers are on a still lower level.
Capacity 16,000 quarts per hour.

bacilli, without thereby changing the taste of the milk and to any extent affecting its value as food for infants. Such a temperature has now been definitely agreed upon as at or about 140° F. for a period of 30 minutes. Pasteurization may be carried on as a wholesale business or conducted as a health measure by the municipality in large central pasteurizing plants, or by the consumer in each household. Pasteurization does not sterilize the milk but reduces very largely the number of air-borne bacteria, and, as stated, destroys all known disease organisms.

Objections to pasteurized milk are made on the following grounds:

That the milk has a "boiled" taste. This is not true unless the temperature at which pasteurization is done is unnecessarily high (above 140° F.).

That the "cream line" is destroyed. This is true to a certain extent, but the disturbance of the cream line detracts in no way from the fat content of the milk.

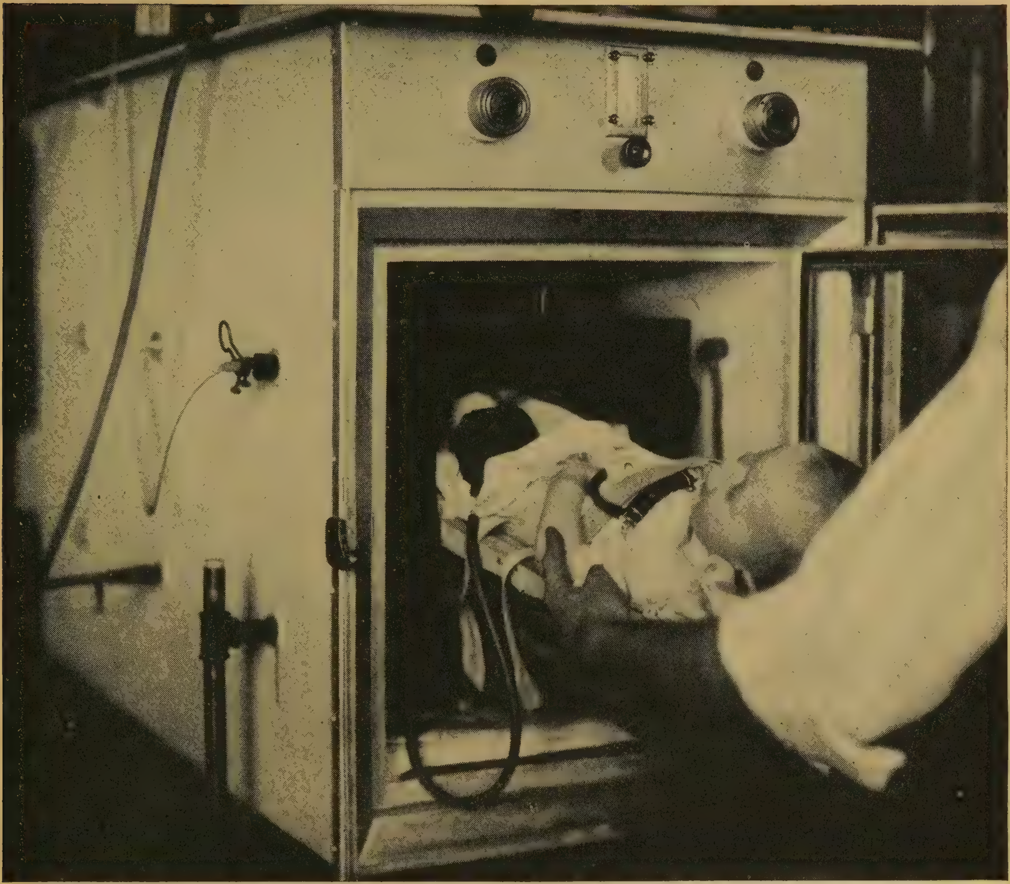
That dirty and stale milk by pasteurizing may be accepted as a suitable food. This is not an argument against pasteurization but rather an argument for con-

AVERAGE HEIGHT AND WEIGHT OF BOYS AT DIFFERENT AGES

Height Inches	5 Yr.	6 Yr.	7 Yr.	8 Yr.	9 Yr.	10 Yr.	11 Yr.	12 Yr.	13 Yr.	14 Yr.	15 Yr.	16 Yr.	17 Yr.	18 Yr.	19 Yr.	20 Yr.
39	35															
40	38	36														
41	39	39														
42	41	41														
43	42	42	42													
44	46	44	43													
45		46	46	45												
46		48	48	48												
47			49	50	50											
48			54	53	53	53										
49				54	55	55										
50				57	58	58										
51				59	60	60	61									
52					62	62	61	63								
53					62	65	65	67	67	67						
54					65	68	68	70	71	71						
55						69	71	75	75	76						
56						71	77	76	78	79	79					
57							77	79	80	82	82					
58							78	84	85	86	87					
59								84	86	90	91					
60								85	91	94	95	90				
61									98	97	99	96				
62									99	103	106	104	105			
63									100	107	112	112	110	118		
64										114	118	120	117	120	120	
65										122	119	122	122	120	126	125
66											121	125	125	126	129	130
67											128	129	128	131	134	132
68											133	133	130	136	136	136
69											134	136	139	139	139	139
70											136	140	143	143	144	145

The importance of protein in the diet has been discussed elsewhere, also the fact that all proteins are not of equal value as builders. Experience indicates that this constituent is frequently deficient in amount and of poor quality for growth. A fairly safe rule is to provide, for growing children, from three-quarters to one gram of protein for every pound of body weight (without clothes) and for adults one-half gram per pound. It is sometimes more convenient to calculate the protein in terms of calories, rather than as grams, and as one gram of protein will yield, when burned in the body, 4 Calories, the requirement per pound of body weight (without clothes) may be stated thus — 3 to 4 Calories from protein for children and 2 Calories from protein for adults. While the child's protein requirement in proportion to body weight is greater than that of adults, so is its fuel requirement, and therefore a convenient method of stating the protein requirement is that on an average the protein must supply from 10 to 15 Calories out of every hundred or in other words from 10 to 15 per cent of the total calories should come from protein. The following chapters will give tables from which the protein content of a diet may be easily estimated. In malnutrition cases the quality of the protein is usually faulty and this may be corrected by including in the diet at least sixteen to twenty fluid ounces of good milk.

Another general dietary fault is deficiency of mineral constituents — especially of calcium, of phosphorus, and of iron.



AUTHOR'S RESPIRATION INCUBATOR FOR THE STUDY OF FOOD REQUIREMENTS IN THE BABY

The child lies on a bed and sleeps. The pulse is recorded by means of a cuff around the child's leg and the number of respirations by means of a small instrument attached to the child's chest. The rubber tube connections pass through the walls of the chamber and transmit the waves of air to recording instruments placed on top of the incubator. The child remains in the chamber about two hours, or the duration of a good nap.

So long as the baby is well and the mother's milk is satisfactory, the baby's appetite can usually be trusted to gage the amount of food to be taken. In fact, it is surprising how accurately the baby will measure with its stomach the calculated requirement. In one case the calculated requirement for twenty-four hours was 18 ounces of the mother's milk, which was being analyzed at the time. By weighing the baby just before and just after nursing each time we found that he had taken altogether in the twenty-four hours 18½ ounces.

Courtesy A. Vivian Mansell & Co.

"THE NEW ARRIVAL", BY WALTER LANGLEY

TYPES OF A GREAT EUGENIC RACE — THE JEWS, WHO GUARD THEIR MOTHERS AND CHILDREN, and, amid extremest poverty, have the lowest infant mortality of all the races in the world.

Nor will eugenists allow the name of eugenics to be used as a cloak or pretext for economic and political reaction. It means not less but more attention on the part of society to the handicapped and endeavor to promote justice between man and man. We must repudiate in the strongest terms the position held in its barest and most stupid form by Herbert Spencer and his followers. It is incredible that intelligent men could imagine either that economic success proves social fitness and economic failure social unfitness, or that success and failure correspond in modern society with biological survival and extinction. Eugenists are therefore the friends, and not the foes, of public education, intelligent organized relief of destitution, and also of the social control of industry wherever it is in the interest of efficiency and justice. Finally, eugenists are not in favor of any social class to the detriment of any other class. They esteem merit, wherever found, and merit only, and the test by which they judge all human institutions is that of the quality of life they produce.

LAW, THE STEADYING FORCE OF SOCIETY

AN ARTIST'S CONCEPTION OF ROMAN LAW—THE BASIS OF THE JUDICIAL SYSTEMS OF TO-DAY

This painting in the Youngstown, Ohio, Court House, is by Edwin H. Blashfield, and is used here by his permission.

Society

SOCIAL science, the study of the relations and the institutions which are involved in man's existence and his well-being as a member of an organized community, has made great strides in recent years. Questions relating to public health, education, labor, punishment and reformation of criminals, pauperism, domestic duties which fulfilled lead to happiness, what the State owes the citizen, what the citizen owes the State—all these are treated in the following interesting chapters by leading authorities.

How Man goes on Forever
The human rebellion against nature

The First Human Families
The rock on which great nations build

One Man and One Woman
The unbreakable bond of marriage

Our Minority of Women
Is it possible to determine sex?

The Marriage Problem
Life from the child's point of view

The Triumph of Woman
Woman as the mother of civilization

Woman's Place in the Sun
Freedom of women in the early world

The Future of Woman
Should married women earn a living?

Society in the Making
Brain capacity in man early and late

Public Opinion—Dictator
The secret of stability in society

Utopias of the Redskins
Some problems of social evolution

The Evolution of Society
The failure to manufacture nations

The Origin of Kingship
Superstition as a social force

The Reign of the Ghost
The origin of fundamental laws

The Ownership of Land
The origin of village communities

The Land and the People
Balance of agriculture and industry

The Religion of Liberty
How freedom is born of law and order

Society and Inventors
What a people miss by liberty

The Revolt of Labor
Anarchism versus social reform

The Problem of Poverty
An evil that confronts the whole world

Successes of Democracy
Great problems that confront it

Problems of Democracy
The new idea of the minimum man

The Ideal Modern City
Things we have or may have seen

The Sphere of Government Activity
How should powers be distributed?

Present Government Problems
The organization of democracy

Citizenship as a Study
The greatest gap in education

Society and Disease
Will state treatment be universal?

Public Health to Come
Duties that society cannot escape

Society and Crime
The incredible crimes of the law

Reclamation from Crime
Training the criminal as a citizen

The State and the Poor
Repression, relief, prevention

Social Aspects of Thrift
Saving as a duty and as a mistake

The Thing that Matters
There is no wealth but life

The People called Eugenists
The forces that make men what they are

More Knowledge Wanted
Steps proposed or already taken

Eugenics and the Future
The true cause of the fall of empires

CITIZENSHIP AS A STUDY

Importance of the Public's Understanding Public Rights, Privileges and Duties

THE GREATEST GAP IN EDUCATION

As we have commented on local attempts to make each village and town approximate more and more to an ideal dwelling-place, a genuine social gathering-ground, where every citizen will help the rest and no one be a danger, and as we have discussed the relations, in administrative work, between the central government authorities and the local governments formed by the taxpayers, the doubt has recurred constantly whether today popular government is popularly understood, and, indeed, whether any serious and consistent attempt is made to cause the young to know the broad facts, or the old to reflect on the broad principles of government. In view of the extension of suffrage to all, is any adequate effort being made to give to all a clear view of sound citizenship?

Quite obviously it is necessary that, if the government of modern nations is to pass into the hands of the populace through universal suffrage — and that is what is here, or is at hand — the thought of statesmen, educators and moralists should be concentrated on giving the populace easy opportunities of understanding the foundation principles of civic justice, helpfulness and stability. In brief, the subject of civics should be regarded as the first study for every man, after he has learned how to work to support himself and those dependent on him. It has, too, a direct bearing on that work of maintenance. And yet no fully organized attempt has ever been made to give this great subject an adequate place in the scheme of education for the young, or for those on the threshold of citizenship.

Such neglect could well be understood in former days, when government was in the hands of a few — of kings and their courts, of the nobility, of the middle classes or of any limited number of selected people. There was no reason why the many should be taught to understand the value of privileges and of legal rights they did not possess, except with a view to broadening ultimately the basis of the political edifice. A haphazard knowledge might suffice for the many when it was unconnected with responsibility. But now all that is changed; and the man who has never given a minute's serious thought to public institutions or affairs will have as much voting power — though, of course, not as much influence on votes — as the profoundest publicist. The least that can be expected of the nation with a universal suffrage is that it shall take the trouble to organize a readily accessible education in the business on which the suffrage is exercised — that is, in the business of public government.

Yet it cannot be said that our efforts in this direction are at all in proportion to the importance of the end, or that the public itself takes its public duties as seriously as it should. The general tone of political discussion in this country before it entered the European war in defense of democracy was distressingly low, and public questions did not by any means excite the interest that they did a generation or two before. In the years since the war there appears to have been a "slump" to even lower levels, due in part to an inevitable reaction and moral weariness after the strain of the war period and in part to dissatisfaction with the conduct

RECLAMATION FROM CRIME

The Modern Attempts by Society to Remove from Itself the Reproach of Neglecting Criminality

TRAINING THE CRIMINAL AS A CITIZEN

IN our last chapter we pictured the growth within society of a clan that practically has not accepted for itself the laws made for the protection of all and by general assent, a clan that, for its own momentary apparent benefit, is at war with civilization. This clan, chiefly located in the considerable centers of population, or wandering through the country, and bred and recruited, for the most part, within a comparatively narrow circle, persists long after men have agreed as to what is real and what is fictitious crime. Time was when any definition of crime divided society widely in opinion; when punishments of a hideous character were in force against so-called offenses that now rank as virtues; but crime is now narrowed down to aggression against life, property or the amenities of life. The range of admitted crime is over a much smaller area; the punishments incurred are less drastic; the treatment of the criminal is not so vengeful, and is more hopeful. Our survey of crime and its punishments, halting at a period of about eighty years ago, was a record of injustice, cruelty and failure. We have now to discuss steps that have been, or are being, taken to remove crime from our midst — a long and gradual process, no doubt, but far more promising than the primitive policy of harsh retaliation.

Although this movement to measure punishments justly and to remember the manhood of the offender had such a recent beginning in law and its administration, it was foreseen in spirit long ago, even in the English world. In that wonderful repository of wisdom "Utopia", Sir Thomas More outlines three objects of a trial of anyone who has broken the laws — the prevention of further mischief, the making of amends for the harm already done and *the saving of the man.* It has taken us nearly four hundred years to learn that final lesson — the saving of the man. More also saw clearly the major mistake that society has made all along with its criminals. Said he, "You suffer them to grow up infected, and then, in God's name, you punish them." A volume could not have told the story more exactly.

Before we refer to the bulk of ordinary crime, for which society itself is responsible largely, owing to its neglect, we must make the admission that, outside of those who are brought up in an atmosphere which conduces to crime, and makes participation in it natural, there are forms of crime that will continue. A certain amount of crime springs up sporadically, in sheer freakishness, out of unbalanced human nature. By a kind of spontaneous generation it breaks out in the most unlikely places, through temptations offered by education, by the handling of money and by the undue influence and prestige associated with money. The sphere of possible fraud has been widened greatly by the growth of commercialism; and ill-balanced minds, associated with laxity of principle, cannot withstand the beckonings of demoralizing suggestion. We know, by statistics, how strangely feeble minds and characters are upset by pressures of outward circumstances that leave others completely untouched.

"HIS FIRST OFFENSE"

FROM THE PAINTING BY LADY DOROTHY STANLEY WHICH VISUALIZES ONE OF THE PROBLEMS OF RECLAMATION FROM CRIME

THE IDEAL MODERN CITY

The Great Common Benefits a Municipality Should Provide, or Insist on, for All of Its Citizens

THINGS WE HAVE OR MAY HAVE SOON

FROM the day when the families of men began to live together for the sake of defense, or for coöperation in hunting or husbandry, the problems of civic government must have existed in elementary forms. The earliest community would have its internal public duties, as well as the external duties of defense, and the securing of the means of subsistence; and at every stage in advancing civilization the growing complexity of these duties would be apparent, until now, wherever we live, the duties, rights, assistances, and restrictions of civic organization hem us in, and, indeed, if we live in cities, become a major part of our lives. Objection to this state of things is entirely useless, for we cannot alter it. Whether we would have it so or not, we are made one family by the cement of the taxes; and the most practical course open to us is to ask how we can perfect that part of our lives which is lived in common with our neighbors. Is it possible to make for ourselves an ideal city? If so, what should its characteristics be?

An ideal city can never be founded on any other bases than the intelligent idealism, foresight and local pride of the citizens. In this respect even piety takes a second place, for knowledge, at present, is broader than piety. "Purify the hearts of your people and the city will be clean" is only a half-truth, for men may be the salt of the earth as far as personal goodness is concerned, and yet, unawares, may be, in some respects, bad citizens. Like Tennyson's village wife, they may attribute the effects of their poisonous sewers to the "will of the Lord".

Given that a city has the power of self-management, and values such power highly, so that all its affairs are matters of keen general interest, and presuming that its best men of business are willing to undertake the administration in a spirit of hearty local pride, then there is no reason why the city should not gradually improve itself into the position of an ideal city, supporting vigorously every institution that is necessary from either a local or a national point of view. What must be the aims that will lead to that end?

Almost without exception, whoever talks about the management of great cities begins with health. The preservation of public health is the subject of the first paragraph in the address of nineteen would-be administrators out of twenty. And very properly so, for health, important in itself, is inextricably interwoven with almost all other subjects of high civic importance, as, for example, with education, housing, recreative exercise, transportation from the crowded districts to the country, and wise and adequate feeding, as well as with formal sanitation. Indeed, half, or more, of the necessities that go to the making of the ideal city might be discussed under the one heading of health.

Now, the first of all desirable things in making the ideal city is space. Unfortunately, it was only late in the day that this fact of prime importance was realized; for in many times and lands other reasons than those of health determined the building of cities. The ruling thought for centuries was defense. The smaller the area to be defended the better, and the houses were crowded on a minimum of ground.

WOMAN—THE INVENTOR OF POTTERY

It was woman, no doubt, who first wove a shelter of interlacing twigs to shield her child from storm and cold; then, improving in the art of plaiting, she made a basket; and by lining this with clay and burning it over a fire she discovered pottery.

THE TRIUMPH OF WOMAN

How the Women of Primitive Days Built the First Homes, Domesticated Man, and Gave Birth to Agriculture, Industry and the Arts

WOMAN AS THE MOTHER OF CIVILIZATION

ONCE it was commonly thought that the brain of man was much larger than that of woman. It has now been found, however, that, in proportion to the size of her body, she has a larger brain. Woman's brain-weight is to man's as 90 is to 100; but then woman's body-weight is to man's as only 83 is to 100. Professor L. Manouvrier, the French anthropologist, goes further than this, and estimates that the active organic mass of woman's body is to that of man's as, at most, 70 to 100.

She is also much less hairy and more delicately built. In short, she is "a child of a larger growth," and she can congratulate herself on this fact. Her superiority in comparative brain-mass, however, implies no intellectual superiority, but is merely a characteristic of short people and children. On the other hand, there seems to be no reason for the belief that women are naturally slightly less intelligent than men. Many of the differences between the adult sexes of civilized communities are due to differences in education. By education we mean not only mental training, but mainly muscular education, bearing on the individual development of the nervous organization.

Man undoubtedly possesses some natural advantages over woman — he is stronger in body, for instance, while the woman is stronger in constitution. This fact has determined the natural division of labor between the sexes. From the beginning man has been the fighting animal, and woman the domesticating force. Woman has made the home, and man has guarded it. Man has invented the weapons of human supremacy over the wild beast, woman has discovered the means of turning plants into food. Man has generally undertaken the work requiring great effort exerted suddenly and for a short space of time, woman has done most of the hard drudgery of existence.

In appearance, a woman of a savage type is the most oppressed creature on the earth. She can still be seen, among the lower hunters, trudging along, carrying a hundred pounds of household utensils, with often her last-born child slung behind her back or straddling over her shoulders. She will walk like this for twenty miles a day. In front of her strides her husband with nothing in his hands except some weapon of defense. "It does look bad," says Bishop Selwyn, "but it is really an excellent division of labor. A savage woman can carry a very heavy burden, but she cannot defend herself as well as a man can."

With a little alteration, this picture of modern savage life can be made to represent the primitive state of the relation of the sexes. The woman bore all the burden, and man walked in front of her with his club or his stone ax, ready to defend his mate and his young from beast of prey or human rival. When human warfare began, more routine work fell on the woman, and more risk and danger on the man. Probably for hundreds of thousands of years the inventive genius of the human male was spent chiefly in devising instruments of destruction. He threw away his wooden club, and began to shape rude axes and weapons of bone and flint; he became cunning in making traps, and wise in the ways of both the animals he feared and the animals he hunted for food.

This index occupies 144 pages and contains over 20,000 entries.

INDEX

THE heavy face number against a reference is that of the volume in which it appears; the light face number gives the page. Where two of the latter are separated by a dash it shows that the reference extends from one to the other. For example:

Photography.
By telephone, *with illus.,* **15**, 5179-5182

indicates that information on the transmission of pictures by telephone will be found in volume 15 on pages 5179 to 5182 inclusive, together with reproductions of photographs sent by telephone. The only abbreviations used are *illus.* for illustration, and U. S. for United States. Cross references at the end of indexed subjects avoid duplication and should be consulted. The alphabetization is that preferred by the American Library Association—that is by first word and not "straight through." For example: **Child Labor** (2 words) precedes **Childbirth; Chimney swift** precedes **Chimneys.**

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